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INSTITUTE FOR DEFENSE ANALYSES

Value Engineering Handbook

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Danny L. Reed, Project Leader

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PREFACE

The Institute for Defense Analyses (IDA) prepared this paper for the Office of the Director, Defense Systems, under a task titled "Total Ownership Cost Reduction." This paper partially fulfills the task objective of supporting initiatives related to Reduction of Total Ownership Cost and Value Engineering (VE) by describing benefits of and opportunities for VE and promulgating information on how to effectively apply VE in today's acquisition environment.

John R. Hiller and James A. Myers of IDA and Charles Waszczak of the Defense Acquisition University were the technical reviewers for this paper.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION AND SUMMARY

In today's environment of reduced budgets and staffing, the Department of Defense (DoD) can no longer afford the extensive time delays and increased costs that programs have experienced in the past. When one program costs more than planned, decision-makers are forced to delay or cancel other programs. Such actions result in criticisms and may prompt outside involvement by the Government Accountability Office, the Inspector General, or even Congress. Value Engineering (VE) can play a key role in ensuring programs stay within budget or even save money.

This document updates information in DoD Handbook 4245.8-H, "Value Engineering," last published in March 1986, and Army Pamphlet 11-3, "Value Engineering" (undated), both of which were used as sources of information. It shows how VE can be an effective mechanism for generating cost savings or cost avoidance for contractors and the U.S. Government. It is intended for multiple audiences. For Government practitioners, it gives details on the basics of the VE methodology and discusses how to establish a VE program. For Government program office personnel, it explains the impact VE can have on their success. For Government contracting officers and industry, it describes best practices for applying VE on Government contracts. For both Government and industry management, it provides an overview of the benefits of a strong VE program.

A. VALUE ENGINEERING DEFINED

VE is an organized/systematic approach directed at analyzing the function of systems, equipment, facilities, services, and supplies for the purpose of achieving their essential functions at the lowest life-cycle cost consistent with required performance, reliability, quality, and safety.[1] The implementation of the VE process on a problem typically *increases* performance, reliability, quality, safety, durability, effectiveness, or other desirable characteristics.

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[1] Office of Management and Budget, "Value Engineering," Circular No. A-131, May 21, 1993 (available at http://www.whitehouse.gov/omb/circulars/a131/a131.htm).

Because “costs” are measurable, “cost reduction” is often thought of as the sole criterion for a VE application, and indeed, cost reduction is primarily addressed in this document. It is, however, important to recognize that value improvement is the real objective of VE, and that may not result in an *immediate* cost reduction.

In fundamental terms, VE is an organized way of thinking or looking at an item or a process through a functional approach. It involves an objective appraisal of functions performed by parts, components, products, equipment, procedures, services, and so on—anything that costs money. VE is performed to eliminate or modify any element that significantly contributes to the overall cost without adding commensurate value to the overall function.

VE is not primarily centered on a specific category of the physical sciences; it incorporates available technologies, as well as the principles of economics and business management, into its procedures. When viewed as a management discipline, it uses the total resources available to an organization to achieve broad management objectives. Thus, VE is a systematic and creative approach for attaining a return on investment (by improving what the product or service does in relation to the money spent on it.

1. VE History

During World War II, many manufacturers were forced to use substitute materials and designs as a result of critical material shortages. When the General Electric Company found that many of the substitutes were providing equal or better performance at less cost, it launched an effort (in 1947) to improve product efficiency by intentionally and systematically developing less costly alternatives.

Lawrence D. Miles, a staff engineer for General Electric, led this effort. Miles combined a number of ideas and techniques to develop a successful methodological approach for ensuring value in a product. The concept quickly spread through private industry as the possibilities for large returns from relatively modest investments were recognized. This methodology was originally termed *value analysis* or *value control*.

In 1957, the Navy’s Bureau of Ships became the first DoD organization to establish a formal VE program. Miles and another General Electric employee, Raymond Fountain, set up the Bureau of Ships program to help reduce the cost of ship construction, which had nearly doubled since the end of World War II. The Bureau of Ships asked that the technique be called “Value Engineering” and staffed the office with people under the general engineer position description.

In 1959, the contractual requirement for VE was added to the Armed Services Procurement Regulation the forerunner of today's Federal Acquisition Regulation (FAR). VE was initially used only with command approval, but in June 1962, the Defense Department's procurement regulations were modified to establish VE as a mandatory program both for the Department and for its contractors.

VE remained basically a DoD program until Office of Management and Budget (OMB) Circular A-131 was issued in 1988 to expand the program into other organizations "where appropriate." OMB Circular A-131 contained some loopholes, which were closed by a 1993 reissuance. The circular now requires that all Federal Departments and Agencies use VE and that OMB be advised annually of top VE projects, and net life-cycle cost savings, cost avoidance, and cost sharing achieved through VE. In 1996, VE was given further support when President Clinton signed P.L. 104-106, which requires each executive agency in the Government to establish and maintain cost-effective VE procedures and processes.[2]

Since its inception, the VE concept has proved to be so successful that today it is practiced throughout the world, with many organizations dedicated to its use and promotion.

The DoD VE program continues to have two distinct components:

- An in-house effort performed by DoD military and civilian personnel; and
- An external effort performed by DoD contractors and applied to contracts after Department approval.

This latter component is extremely important. The mandatory VE provisions in most DoD contracts encourage contractor participation and thereby realize the full benefits from cost reduction opportunities and innovations. These contract provisions provide the basis for the contractor to obtain a share of the savings that result from an approved VE effort. Before this development, submitting a cost-reduction change led to a commensurate decrease in the size of the contract and usually reduced profit by a proportional amount. The VE provisions changed this paradigm by providing the contractor with an incentive to submit proposals to reduce cost.

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2 Title 41 USC, Section 432, "Value Engineering" (available online at Cornell University Law School's Legal Information Institute site at http://www4.law.cornell.edu/uscode/html/uscode41/usc_sec_41_00000432----000-.html).

2. VE Terminology

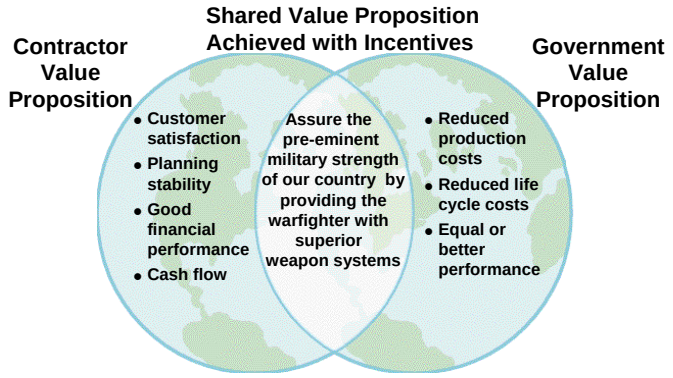
The term *Value Engineering* is synonymous with value management, value analysis, and value control. Some of these terms were coined to minimize confusion about the word *engineering*. You do not have to be an engineer to apply VE. The following terms are used throughout this document:

- ***Value Engineering Project:*** A preplanned effort to study a specific area or task, the primary objective being to improve value using VE methodology while maintaining required functions.
- ***Function:*** The purpose or use of an item or process. The VE approach first concerns itself with what the item or process is supposed to do. The consideration of function is the fundamental basis of the VE method.
- ***Value:*** The relationship between the worth or utility of an item (expressed in monetary terms) and the actual monetary cost of the item. The highest value is represented by an item with the essential quality available at the lowest possible overall cost that will reliably perform the required function at the desired time and place.
- ***Worth:*** The lowest cost to reliably achieve the required function. Worth is established by comparing various alternatives to accomplish that function and selecting the lowest cost alternative.
- ***Value Engineering Proposal:*** A specific proposal developed internally by DoD personnel for total value improvement from the use of VE techniques. Since Value Engineering Proposals are developed and implemented by Government personnel, all resulting savings accrue to the Government. A Value Engineering Proposal can also be the result of a technical support contractor effort if it is funded by the Government specifically to conduct a VE study on a contract to which it is not a party.
- ***Value Engineering Change Proposal (VECP):*** A proposal submitted to the Government by the contractor in accordance with the VE clause in the contract. A VECP proposes a change that, if accepted and implemented, provides an eventual, overall cost savings to the Government and a substantial share in the savings accrued as a result of implementation of the change for the contractor. It provides a vehicle through which acquisition and operating costs can be reduced while the contractor's rate of return is increased.

General information about VE can be obtained from the Web site http://ve.ida.org.

B. VE BENEFITS

As depicted in Figure 1, the Government and its contractors depend upon each other to improve their joint value proposition.



Source: Adapted from research into economic initiatives as a result of the Lean Aerospace Initiative.

Figure 1. Joint Government Industry Value Proposition

While the value propositions are different, there is overlap; actions that benefit one can benefit the other. Incentives are typically used in the contract so that the contractor behaves in a way that will enhance both value propositions. VE provides, and is based on, a shared value concept through incentives for the Government, incentives for the contractor, and the equally shared incentive of providing the best possible warfighting capability and systems to the military within the context of a successful business relationship. VE gives industry the incentive to use its best engineering talent in a way that helps solve problems that are important to the Government.

1. Benefits to the Department of Defense

In today's market, VE has proven to be a sound economic venture. Its overall record of performance (where it has been intelligently applied, discreetly managed, and honestly reported) is impressive. From 2000 through 2005, the average return on investment within the Defense Department was 7.6 to 1. Figure 2 shows DoD VE savings and cost avoidance since fiscal year (FY) 1981. Cumulatively, more than $30 billion has been saved, with an average savings of about $1 billion annually.

Equally important is how the savings are used. The dollar savings/assets made available through VE successes may be reapplied within the program, command, or component to finance approved but previously unfunded requirements.

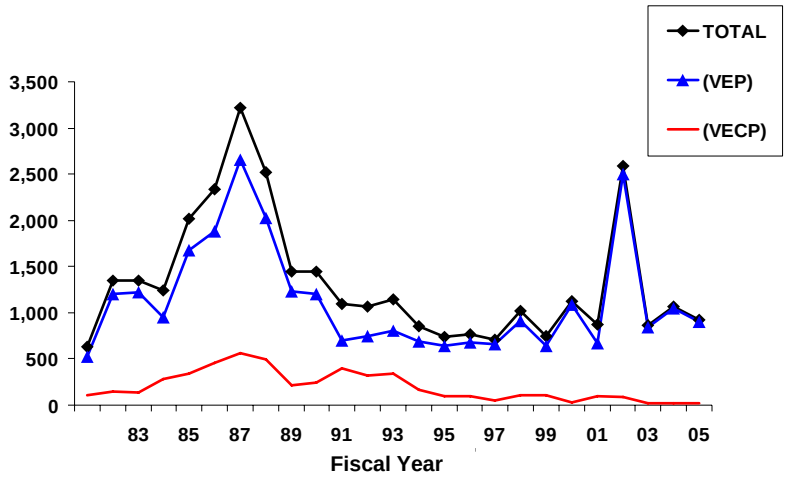


Figure 2. DoD VE Savings and Cost Avoidance

From a qualitative perspective, VE creates opportunities for the Defense Department to achieve long-term benefits in cost reduction, communications, procedures, waste reduction, performance, efficiency, reliability, producibility, quality, effectiveness, readiness, warfighting capability, cycle time, and so on. Conceptually, if VE is planned prior to contract award, the contract can be structured to better take advantage of VECP savings that might develop (e.g., unfunded options that can be exercised with the acceptance of a VECP). In addition, the program manager may take steps to emphasize that VE is "planned for" and is therefore an encouraged outcome.

2. Benefits to Contractors

From the contractor's perspective, the benefits of using VE are also substantial. The contractor:

- Shares in the savings that accrue from implementation in that VECPs provide a source of profit not available under other provisions of the contract and excluded from profit limitations on Government contracts;
- May increase the work to be performed on the contract if the Government share is placed back on the contract for previously unfunded efforts;
- May secure a price advantage during system re-procurement after implementing a successful VECP on a previously completed system/item;
- Establishes a reputation as a cost-conscious supplier (the Defense Department presents VE Achievement Awards to contractors);
- Improves communication with the customer;

- Receives reimbursement of development cost on approved VECPs to the extent that such costs are reasonable, allowable, and allocable;
- May obtain usable technology for other product lines; and
- Enhances the retention and growth of corporate technical expertise through advanced technology insertion and fostering a positive working environment.

Each of these benefits is relatable to the elements of the contractor value proposition shown in Figure 1—customer satisfaction, planning stability, good financial performance, and cash flow. Government personnel need to recognize that contractors take advantage of these benefits by bringing forward VE proposals.

C. POTENTIAL VE APPLICATIONS

Many items in the DoD inventory are procured in accordance with Government-developed specifications in large quantities on a regular basis. Due to advances in technology, materials, and processes, the applicable specifications may be outdated, and "technological regression" by a contractor may be needed to produce to the existing specifications. Items in this category are good candidates for a VE project. Costly, non-value-added contract requirements not directly related to the specifications should not be overlooked, however. For example, packaging, shipping requirements, management reports, etc. may represent a target of opportunity that will require little or no investment by the contractor to achieve a reduced cost of performance under the contract.

Another opportunity for VE occurs when an item was designed and developed on a stringent schedule to meet urgent requirements. Under these conditions, the designers often incorporate "old, reliable" components or subsystems into the design simply because time will not permit qualification of an improved substitute. However, a newer, less expensive, and more reliable alternative may have been developed and proven since the original system development. When this situation arises, a VECP to incorporate the improved item or subsystem should be considered.

Diminishing manufacturing sources and material shortages provide significant, and potentially funded, opportunities for VE. DoD Components are beginning to program resources to mitigate these very serious problems. Such resources could be a source of funding for nonrecurring costs associated with a VE project. In addition, diminishing manufacturing sources and material shortages may also be established as a life-cycle cost element for categorizing and identifying cost savings.

As discussed in Chapter II, typical opportunities for VE projects will be derived from a known problem, a cost driver study, or anything indicating that a product or a

process should be improved. In the early stages of VE application within an organization, sophisticated project-selection criteria are not usually needed. Frequently, numerous opportunities exist for VE to offer substantial benefits, such as eliminating high-cost drivers; improving performance, reliability, or producibility; or resolving executive management interest issues.

VE is applicable to all aspects of systems, equipment, facilities, and procedures. This wide range of possibilities is best illustrated by the Defense Department's annual VE awards program, which was established to recognize those individuals and organizations whose efforts have made significant contributions to the Department by identifying VE-related changes that resulted in cost savings or avoidance, quality improvements, or efficiencies. In addition, special recognition is given to initiatives that demonstrate innovative approaches and applications that expand the benefits of VE beyond their traditional scope. Chapter II also summarizes, by DoD Component, some of the projects associated with the FY 2004 VE awards.

VE is applicable at any point in the life cycle, but the savings potential decreases as the program ages. VE should therefore be applied as early as possible in the program life cycle. Early VE tends to produce greater savings (or cost avoidance) because that is where most of the costs are committed—there are greater opportunities for change, and the changes cost less to implement.

However, if early opportunities are missed, VE can still be applied. Late in a program VE is precluded only in those rare instances where the cost of the VE effort and subsequent implementation would be greater than the savings potential. Many systems remain in inventory for a substantial amount of time, often longer than originally planned. While later VE normally adds implementation costs and affects smaller quantities, such deterrents can be offset by improved performance and reliability through advances in technology and by savings generated from increased product life. Some opportunities offer net savings at any stage of a program. Chapter III describes VE opportunities early in the life cycle, during production, and after fielding in a systems-engineering context.

D. VE METHODOLOGY

The VE methodology (referred to as the "job plan") can be applied to any subject or problem. It is a vehicle to carry the project from inception to conclusion. By adhering to certain formalities, the VE job plan ensures that consideration is given to all necessary

facets of the problem. Although the job plan divides the study into a distinct set of work elements, judgment is necessary to determine the depth to which each phase is performed as a function of the resources available and the results expected.

The VE job plan divides the task being studied into functions. It provides time for the essential creative work and its necessary analysis so that the best choices can be made for further development. The job plan leads to the establishment of an effective program aimed at the selection of best value alternatives. It concludes with specific recommendations, the necessary data supporting them, the identification of necessary implementing actions, a proposed implementation schedule, and a required follow-up procedure.

The job plan is normally organized by a value team leader. It is conducted in eight sequential phases (which may overlap in practice) as follows:

1. *Orientation Phase:* Refine the problem and prepare for the value study.
2. *Information Phase:* Finalize the scope of the issues to be addressed, targets for improvement, and evaluation factors while building cohesion among team members.
3. *Function Analysis Phase:* Identify the most beneficial areas for study.
4. *Creative Phase:* Develop a large number of ideas for alternative ways to perform each function selected for further study.
5. *Evaluation Phase:* Refine and select the best ideas for development into specific value-improvement recommendations.
6. *Development Phase:* Determine the “best” alternatives for presentation to the decision-maker.
7. *Presentation Phase:* Obtain a commitment to follow a course of action for initiating an alternative.
8. *Implementation Phase:* Obtain final approval of the proposal and facilitate its implementation.

The Orientation Phase is conducted in preparation for the value analysis. This phase, which may last several weeks, lays the groundwork for an efficient and productive study by refining the problem statement, collecting much of the data needed, and organizing for the efforts to follow.

Phases 2 through 7 of the job plan cover the value study. The more analytical steps in the job plan, they are typically performed in a workshop setting involving all stakeholders. Systematic pursuit of the methodologies within these phases leads to

recommendations for improving the existing situation, thereby increasing value for everyone involved. They conclude with a presentation of recommendations for improvement to the decision-maker.

The Implementation Phase occurs after the value study is over and decisions have been made. It monitors the approval process and implementation of the action plan. The name of the phase may be slightly misleading. Project approval is normally not given solely on the basis of the brief presentation that occurs at the conclusion of the workshop. Approval will usually be obtained after the completion of follow-up actions such as providing more data and meeting with others. Implementation itself begins when the final approval is granted.

A prime factor in the success or failure of a study is how VE team members conduct themselves in various situations:

- Contacts between members of the VE study group and their sources of information,
- Relations within the VE study group, and
- Contacts with persons who have the authority to approve or disapprove the changes recommended by the VE team.

"People problems" are sometimes more difficult to resolve than technical problems. For a VE project to be successful, people from all levels in an organization must cooperate to develop a dynamic and creative spirit. Favorable attitudes toward and acceptance of a new concept are based upon positive individual experiences building upon one another over a period of time. Applying general principles of social behavior can promote cooperation in overcoming roadblocks and thereby gaining enthusiastic acceptance of VE. Chapter IV introduces the job plan, discusses some of the people-oriented issues, and addresses how to use the methodology to solve the "right" problem. Chapter V discusses the methodology in greater depth.

E. ESTABLISHING A VE PROGRAM

Applying VE to reduce cost and improve performance on a continuous basis involves a systematic approach for managing a VE program within an organization, providing practitioners with the necessary training, working with contractors to encourage and support their participation, expediting contractual approval, and sharing pertinent information with others who want to do the same.

1. Establishing a VE Program in Government

A VE program cannot be established in a vacuum. It must be fully integrated with other organizational activities. Because VE can be thought of as an enterprise change initiative, comparisons are often made to other enterprise change models. Approaches will always have differences, however:

- Each approach will have its own identifiable evolutionary path.
- Some tools and characteristics will be strongly tied to a single approach.
- Each approach may have a different goal, focus, scope, or business model.
- Terminology will be different.
- Individual circumstances can lend themselves to one approach over another.

The differences are not important. All such models will provide a positive impetus for performance improvement and change, thereby enabling organizations to drastically improve their bottom lines. Each approach will use its own process—these processes work, the value methodology works. In fact, the boundaries will merge in practice. While each approach may have strengths, rarely will a single approach be right for all aspects of a given situation. The complementary nature of the different approaches will lead to synergistic benefits. Chapter VI describes such interrelationships with some enterprise-wide initiatives used in the Department of Defense.

Top management support, institutionalized in written policy that is adequately resourced, is a prerequisite for a successful VE program. Leadership attention will ensure implementation and continuing support from the entire organization. Setting goals and objectives that are linked to the organization's affordability initiatives and can be tracked through metrics provides both a rationale for change and an impetus to succeed.

A designated VE leader with open communication channels to top management is also important. That person should have established credibility as a problem solver and possess both people and management skills. Chapter VI also lists some of the leader's responsibilities.

One such responsibility is providing VE education and training. Nearly all colleges and universities teach disciplines related to the practice of VE. Within the Defense Department, the Defense Acquisition University offers a course on the contractual aspects of VE along with an online continuous-learning VE overview module. SAVE International is an international society devoted to the advancement and promotion of the value methodology. SAVE International offers member services such as education and

training, publications, tools for promoting the value methodology, certification, networking, and recognition. SAVE also maintains a directory of "value consultants" who can lead studies or train others in VE techniques, and it sponsors courses covering the value methodology in depth as well as related disciplines. In addition, private companies provide VE training for their own employees and their customers. Chapter VII provides additional information about these sources.

2. Performing VE on Government Contracts

The basic VE provision in a contract is the VE incentive (VEI) clause in the FAR. The VEI clause is included in most supply/service contracts when the contract price exceeds $100,000. It may also be included at lower thresholds. For example, using the clause for spares/repair kit contracts over $25,000, if the contract is not for standard commercial parts, is a common practice among many DoD organizations. The VEI clause may be included in contracts under $100,000 if the contracting officer sees a potential for significant savings. If the VEI clause is in the contract, contractor participation is voluntary, but the FAR also contains provisions, known as the VE program requirement (VEPR) clause, that require a mandatory VE effort by the contractor. The VEPR clause may be included in initial production solicitations and contracts for major programs if the contracting officer determines that significant savings may result from a sustained, specified VE effort.

Approved VECPs, submitted under the VEI clause, become the basis for modifying a contract to incorporate VE. Before preparing a formal VECP, the contractor should sell or market the VE idea through clear communication with the procuring activity. This enables the contractor to get an indication from the Government of whether a potential idea should be pursued before significant investments are made. The contractor should become acquainted with the Government point of contact or VE advocate who will have the responsibility for evaluating and accepting or approving the VECP. A potential VE idea should be presented early to the appropriate points of contact.

When the contractor makes the decision to submit a VECP, those responsible for preparing it should realize that the chance of the VECP being approved is proportional to the completeness of its preparation. Sufficient information must be presented so that the Government can conduct a thorough evaluation within a reasonable amount of time. Failure to provide adequate data will usually result in requests for additional data (which significantly delay the process), but it could also result in the VECP being rejected.

Contractors should prepare a VECP using an approach similar to responding to a formal procurement solicitation. FAR 52.248-1 provides the basis for contractors to submit VECPs in supplies or services contracts. When contractors participate in the VE program by originating, preparing, and submitting VECPs, they will be rewarded for their (and any of their subcontractors') ideas if the ideas are adopted by the procuring activity. FAR Part 48 and 52.248-1 describe the definitions of terms used in VE, the criteria for VECP acceptance, and approved sharing rate.

While an untapped potential exists for flexibility and tailoring the FAR to accommodate the needs of the Government and its contractors, extenuating circumstances in today's contracting environment often add complexity to the VECP process and consequently discourage the use of VECPs.[3] Chapter VIII provides more about VE from a contractor's perspective.

3. Improving VE Expertise in Government and Industry

One of the most effective ways of improving expertise in a subject is to link knowledge seekers with knowledge sources (both written and experiential). Communities of practice (CoPs) are proven vehicles for linking people with experience to others who can benefit from their insight and knowledge.

A CoP is a group of individuals with similar interests that works together to facilitate communication, share knowledge, and solve common problems. CoPs cross organizational lines and geographical boundaries. By nurturing a trust-based culture, CoPs foster interaction among people at different levels and with varying subject matter expertise; they enable personal relationships with leaders in the field. By providing a safe environment to share challenges, exchange best practices, and test new ideas, CoPs stimulate collaboration and innovation.

Such an approach is being applied to VE. The CoP initially focused on VECPs has been organized to help practitioners share and learn from one another. The CoP can be accessed by going to the Defense Acquisition University's Acquisition Community Connection Web site, https://acc.dau.mil/vecp. The CoP will help participants navigate the VECP process, improve the probability of successful VECP evaluations, provide assistance and answers to technical questions, and serve as a forum for disseminating the

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3 Refer to *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts*, IDA Document D-3046, Mandelbaum and Reed, October 2006.

latest information. Contracting officers, VE practitioners, program offices, and industry are all encouraged to use this CoP to share and build on the material contained in this document. Chapter IX contains the bulk of the material from the Web site and discusses the motivation for this CoP in greater detail.

II. OPPORTUNITIES FOR VE APPLICATION

Section A identifies some characteristics of worthwhile VE projects that can be used to establish project-selection criteria. After listing potential VE application areas, Section B summarizes recent examples of actual VE projects the DoD Components have conducted.

A. SELECTING VE PROJECTS

Like any profitable endeavor, a successful project is based on an adequate return on investment. While almost any activity is a possible VE opportunity, selecting VE projects should be based on the potential yield from the time, talent, and cost that will be invested.

Typically, opportunities for VE projects will be derived from a known problem, a cost driver study, or anything indicating that a product or a process should be improved. In the early stages of VE application within an organization, sophisticated project-selection criteria are not usually needed. VE can frequently offer substantial benefits, particularly when one or more of the following applies:[4]

- High cost;
- Deficiencies in performance, reliability, or producibility;
- Multiple product applications; or
- Executive management interest.

Once the organization's use of VE is more fully established, additional criteria may be applied to select subsequent tasks. Worthwhile candidates usually involve one or more of the following:

- Excessively complex product;
- Design that uses the most advanced technology;
- Accelerated development program;
- Item that field use indicates is deficient in some way, such as high failure rate, low reliability, or low availability;

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[4] Adapted from information in Army Pamphlet 11-3, "Value Engineering" (undated), and DoD Handbook 4245.8-H, "Value Engineering," March 1986.

- Item that uses older technologies for which modernization appears promising;
- Process with long cycle time; or
- Sole-source procurement.

Candidates with both the potential for high impact and leadership interest in finding a solution should be ranked highest.

VE can also be used to measure the merit and the risk of a new or changed process (before a problem is identified),[5] as well as:

- Eliminating or controlling potential process failures;
- Identifying process parameters that need additional or improved controls to prevent process failures;
- Confirming which elements of a process are robust; and
- Improving product safety, quality, cost, and schedule.

VE should be applied as follows:

1. Form a multidisciplinary team.
2. Identify process functions.
3. Identify potential failure modes.
4. Calculate a risk priority number as a function of the probability the potential failure will occur, the seriousness of the failure, and the probability of detecting a defect.
5. Identify controls to detect or eliminate the failure cause.
6. Develop actions to reduce risk.
7. Reassess the risk priority number with the corrective actions in place.
8. Assign actions and track them.

VE has proved effective in environments such as engineering laboratories, test facilities, procurement operations, construction projects, manufacturing facilities, and maintenance depots. It has been applied to a broad spectrum of items, procedures, systems, software, equipment, and so on.

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5 This application is based upon work presented by Glen Curtis, "Process Failure Modes Effects Analysis (PFMEA): 'Reduce Process Risk,'" at the Conference on Quality in the Space and Defense Industries, 21–22 March 2005.

B. EXAMPLES

VE is applicable to systems, equipment, facilities, and procedures. The following are some of the areas in which VE has been applied in the Defense Department:

- Construction;
- Design or equipment modifications;
- Equipment and logistics support;
- Facilities and hardware;
- Manufacturing processes;
- Materiel handling and transportation;
- Packaging/packing and preservation;
- Procurement and re-procurement;
- Publications, manuals, procedures, and reports;
- Quality assurance and reliability;
- Parts obsolescence;
- Salvage, rejected, or excess material;
- Site preparation and adaptation;
- Software (computer) programs and flow charts;
- Software architecture development;
- Specifications/drawings;
- Technical and logistics data;
- Testing, test equipment, and procedures;
- Tooling; and
- Training.

The Defense Department's annual VE awards program recognizes individuals and organizations that have made significant contributions to the Department through identification of VE-related changes resulting in cost savings or cost avoidance, quality improvements, or efficiencies. In addition, special recognition is given to initiatives that demonstrate innovative approaches and applications that expand the benefits of VE beyond their traditional scope (i.e., software; environmental protection and conservation; energy conservation; organization; process; service; performance; reliability; quality; etc.). The remainder of this chapter summarizes, by DoD Component, some of the projects identified in the justification for the FY 2004 VE awards.

1. Army

a. Battery Elimination On-line Device

Expendable, risk-prone, and difficult-to-dispose-of batteries were used to power training devices at the National Training Center and the Joint Readiness Training Center. VE was used to develop the Battery Elimination On-line Device, which provides non-interrupted power with a life expectancy of 20 years. Elimination of stock and disposal of batteries is expected to save $9.8 million over just 3 years; lifetime savings will be proportionally higher.

b. UH-60 Tail Rotor Blades

Fifty-seven new UH-60 tail rotor blades were scheduled for purchase to replace units deemed not repairable because of trailing edge bond separation. VE was used to initiate action to analyze and inspect the units deemed not repairable to determine candidates for repair. As a result, engineers designed repair tooling and developed technical data in the form of a Maintenance Engineering Order authorizing repair of trailing edge bond separation. All assets classified as repairable were then sent to the Defense Logistics Agency for induction on current repair lines. Total savings is estimated to be $6 million.

c. H-368/VRC Headset

The H-368/VRC headset is used by infantry passengers in military combat vehicles. It accurately reproduces audio communication signals from intercommunication systems and attenuates ambient noise both actively and passively. The headset (with microphone) allows the wearer to perform duplex communications with the AN/VIC-3 intercommunication system when appropriately configured. It interfaces and provides full functionality with the Full Function Crew Station or Monitor-Only Crew Station. A VECP was implemented to adopt new commercial-off-the-shelf technologies and develop a cost-competitive headset with enhanced performance and improved comfort for the Army users. As a result, the Government saved $ 6.1 million in FY 2004, with more savings expected in FY 2005 and FY 2006.

d. Demilitarization

The Army used VE to develop a less expensive means of destroying an estimated 600,000 tons of captured enemy ammunition in Iraq. As a result, M42/M46/M67 submunitions obtained from munitions in the Resource Recovery and Disposition Account were defused and repackaged for use in lieu of Comp C4 blocks to initiate the open detonation of the captured enemy ammunition. Savings are estimated to be $2.7 million, not including the additional benefit of reducing demilitarization inventory in the continental United States.

e. Hamilton City Ecosystem Restoration Project

The Army Corp of Engineers was given a project for ecosystem restoration and flood damage reduction along the west bank of the Sacramento River in Glenn County, California, about 85 miles north of the city of Sacramento. Early in the effort, six alternatives had already been developed. VE was used to identify 10 alternative refinements or new alternatives to explore. After the VE study's recommendations were incorporated, the $51.2 million alternative that had been selected from the original six alternatives was priced at $44.9 million.

2. Navy

a. Common Organizational-Level Armament Support Tester (COAST), AN/AWM-103

The Navy was using 11 different and obsolete armament test sets for release and control for preflight operational checks of various missile and ordnance launch interfaces on aircraft both ashore and afloat. Using the VE methodology, the AN/AWM-103 COAST was developed as a single test set replacement. It provided reliability improvement, eliminated obsolescence issues with legacy test sets, increased readiness, and reduced organizational- and intermediate-level maintenance requirements. Implementing this single solution avoided the cost of upgrading and maintaining the previous 11 different systems. Fielding this new system is expected to result in a net cost avoidance of $168.9 million.

b. Controller Display

The Navy uses an Automated Electrolytic Oxygen Generator (AEOG) on SSN-688 and SSBN-726 submarines. The existing AEOG controller display was expensive and unreliable. A VECP was submitted to use a new display unit with new technology that offered procurement cost reduction of 80 percent and an increase in the mean time between failures of 300 percent. The new AEOG Display Unit has successfully completed all stringent test requirements, including survivability, reliability, and maintainability. Audited net production savings to the Government from this change are $1.8 million over a 6-year period.

c. SSQ-110A Sonobuoys

SSQ-110A sonobuoys are an active acoustic system that provides significant improvement over existing active sonobuoys and ameliorates the loss of long-range, passive acoustic detection capability. Current aging stockpiles of these sonobuoys were experiencing significant reliability problems. This, in turn, affected crew confidence in the system, as well as operational effectiveness during tactical employment on station. Interrupting the search progression to replace failed sonobuoys resulted in a net reduction in system effectiveness. VE was used to develop a rework and inspection strategy that included new O-ring seals, a new 9-volt battery, and new seawater batteries. The arrival of refurbished units helped personnel to accept active prosecution as a viable tactic and enabled quality training to be conducted. Cost savings and avoidances are estimated to be $40.7 million over 6 years.

3. Air Force

a. KC-135 Wheel and Brake System

The KC-135 wheel and brake system currently has an outdated 1950s steel brake design. Over the past 50 years, wheel and brake technology has improved greatly. VE was used to redesign the brake system to last a minimum of 1,000 sorties and redesign the main wheel to have a 25,000-mile fatigue life. Most important, from a safety perspective, the redesign ensured that the new brakes have the capability to stop a fully loaded KC-135 aircraft in a rejected takeoff situation, with all brakes in a fully worn condition. Because the new system lasts 10 times longer than the old, mission readiness improved. Cost savings were $620 million.

b. NS50 External Shield Elimination

External shields used to protect critical guidance control and computer parts on the Minuteman III intercontinental ballistic missile system from nuclear environments were expensive. Because the high-cost critical material in the shields was difficult to use, manufacturing costs were high. Applying VE yielded several benefits. Shielding was integrated into the chassis construction of the Missile Guidance Set Control and the Missile Guidance Computer. The new chassis constructions were improved with a rugged coating, thus eliminating the need for the external shields. Benefits include:

- Reduced cost in the production program estimated to be $32.9 million for 348 systems.
- Elimination of the shield inspections at the repair depot and in the operational wings. Savings are estimated to be 2 hours per incoming system inspection from either the depot or production line. There is an additional 1-hour savings per system deployment over the remaining life of Minuteman III.
- Reduced repair and replacement activities by the deployment crews due to reduction in guidance system rejections caused by accidental/incidental damage during the installation process.

4. Defense Logistics Agency

DLA award-winning projects, conducted in conjunction with the cognizant program offices, include the following.

a. F-16 Leading Edge Flap Rotary Actuator (LEFRA)

F-16 aircraft employ movable flaps on the leading edges of their wings. Older (pre-block-40) models use a Time Change Interval (TCI) of 3,300 hours, the equivalent of 11 years of operation, for their LEFRA system. As severe supply problems materialized, VE was employed by the Defense Supply Center Richmond and the Air Force to explore alternatives. Because newer LEFRA systems were realizing an 8,000-hour TCI, three extended life tests were conducted on the older units. In each test, the used LEFRA units demonstrated that much more than 3,300 hours of safe operating life were available, allowing the Air Force engineer to extend the TCI while maintaining original 2:1 factors of safety. The result of this project is that replacements for 737 U.S. Air Force LEFRA units can be postponed for more than 2 years, avoiding the actuator, labor, and downtime costs. Further savings may accrue from foreign military sales of F-16s. Current cost

avoidance calculations exceed $3.96 million, with greater savings expected when more demand data become available.

b. Marine Corps AH-1W Helicopter Battery

Production lot test requirements associated with contracts for the AH-1W helicopter battery prevented the manufacturer from efficient delivery. Working with the supplier, Defense Supply Center Richmond developed alternative test methods to ensure better quality while avoiding the excess costs. The VECP incorporating the changes generated $22,000 savings on the instant contact. Anticipated savings in future years exceed $500,000.

c. Aircraft Temperature Transmitter

Defense Supply Center Richmond was experiencing both erratic supply and long lead times for an aircraft temperature transmitter. VE was applied. Research indicated that several companies supplied similar items, but manufacturing data were not available. Defense Supply Center Richmond worked with one of these companies to develop a new product, meeting all of the original form, fit, and function requirements, and worked with the military services to obtain approvals. Procurement savings to date have totaled $37,000. More important, the production lead times were halved, eliminating supply problems with this and similar items.

d. Circuit Card Assembly

A critical application card assembly with only one approved manufacturer appeared to be overpriced. As a result of VE, additional companies with the same manufacturing capabilities and a willingness to fabricate the assembly were identified. An engineer worked with a new source to compile a technical data package for engineering support activity evaluation. After final approval of the new source, procurement costs were reduced by $300,000.

e. Radio Transmitter Buoy

U.S. Navy submarines had been using four older technology buoys that could only be set to operate at one frequency. VE was used to replace the four single-frequency transmitter buoys with a single multifrequency buoy. Another upgrade was to replace the

tape-recorded message device with a digital recorded message device. This project has an estimated annual acquisition savings of $1 million.

f. Machine Gun Barrel

The M134 Minigun is an air-cooled, six-barrel Gatling gun capable of firing 3,000 rounds of 7.62 mm ammunition per minute. M134 barrels are currently replaced after each 100,000 rounds fired and typically still have significant life remaining. VE was used to identify an alternative process. A barrel wear/erosion gage was identified to safely, accurately, and inexpensively assess remaining barrel life. This gage is expected to extend the life of a barrel past the 100,000-round interval and generate an estimated annual acquisition savings of $462,000.

5. Defense Finance and Accounting Service (DFAS)

a. Electronic File Room

VE was used to reduce storage costs and improve the response time on customer requests for DFAS-Columbus. The project converted contractual documents to indexed electronic images, thereby eliminating the cost of maintaining a file room to store and retrieve documents. It allowed DFAS to vacate a 58,000-square-foot file room and reduce the staff from 21 to 2. It also reduced the turnaround time for fulfilling a contractual request from 24 hours to nearly instantaneous. Net savings were approximately $3.3 million.

b. Audit Command Language

DFAS-Columbus had been using a manual examination process for commercial payment vouchers for defense agencies, the Army, and the Marine Corps. VE was used to formulate a project to automate the process by designing edit scripts that match data with other systems, ensure the use of legal and regulatory data elements, and validate "voucher-to-system" information. It was the first time that the off-the-shelf software program (Audit Command Language) was adapted to this problem. Net first year savings exceeded $376,000.

6. Defense Contract Management Agency

Defense Contract Management Agency award-winning projects, conducted in conjunction with the cognizant program offices, include the following.

a. Joint Stand-Off Weapon (JSOW)

Four VECP projects were implemented on the Navy's JSOW Block II program effort. A less costly cold-gas design replaced a hot-gas design for the wing deployment driver; some cost savings were achieved by eliminating costly long-lead components. By replacing the 56-volt actuator battery and 28-volt system battery with a single battery that provides both voltages, cost savings were obtained by reducing the number of mechanical features needed to clamp and connect to the battery. Incorporating materials and processes used in several other commercial off-the-shelf designs currently in full production for the Global Positioning System antenna led to additional savings. Finally, redesigning the power converter to use the aircraft power source generated further savings from economies of scale with all other JSOW variants. In total, estimated savings to the Government will be nearly $8 million.

7. Concluding Comments

Many opportunities for VE savings exist in all aspects of DoD programs. While the examples here are formally recognized programs, numerous other untapped opportunities are available for achieving savings and efficiencies if organized efforts are undertaken to identify appropriate candidates.

III. VE OVER A SYSTEM'S LIFE CYCLE

VE can be applied throughout the life cycle of a DoD system. Section A describes the overall DoD Systems Acquisition Framework[6] and indicates areas with the greatest potential for achieving VE benefits. The remainder of the chapter provides specific VE opportunities during each phase of a system's life cycle in a systems-engineering context. Section B discusses VE early in the life cycle. VE during production and deployment is covered in Section C. Finally, Section D illustrates VE in the Operations and Support (O&S) phase.

A. INTRODUCTION

The Defense Acquisition Management Framework is characterized by five phases separated by three major milestone decision points, as depicted in Figure 3. The five phases are:

- Concept Refinement,
- Technology Development,
- System Development and Demonstration,
- Production and Deployment, and
- O&S.

The three major milestone decision points are:

- Milestone A authorizes the Technology Development phase;
- Milestone B is typically formal program initiation; and
- Milestone C approves Low-Rate Initial Production.

The Design Readiness Review marks the transition from system integration (design) to system demonstration (build and test). The Full-Rate Production decision is made after initial operational test and evaluation have been completed. Initial Operational Capability

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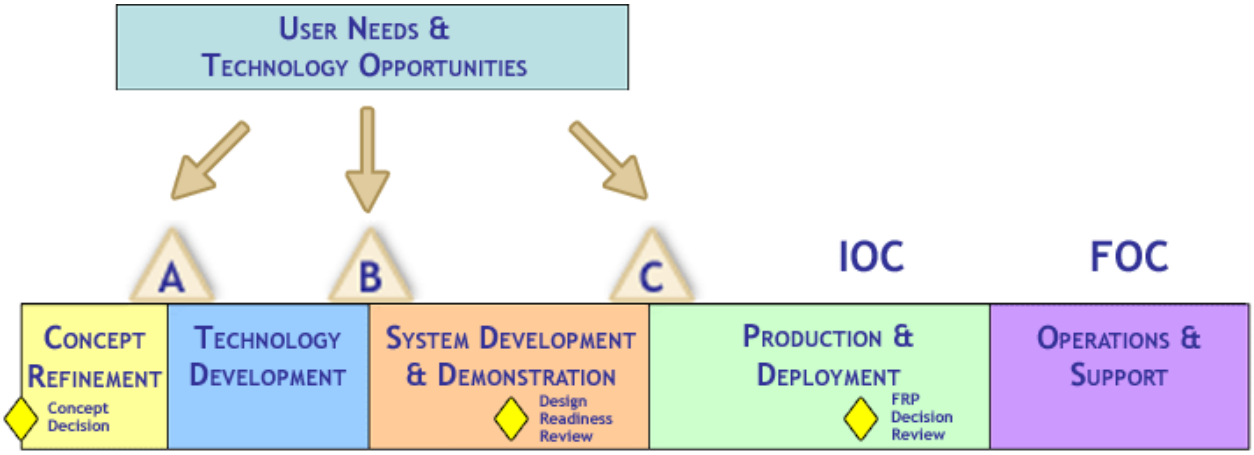
6 See Department of Defense Directive 5000.1, "The Defense Acquisition System," 12 May 2003, and Department of Defense Instruction 5000.2, "Operation of the Defense Acquisition System," 12 May 2003.

(IOC) and Full Operational Capability (FOC) are achieved as the production units are fielded.



Source: DoD Instruction 5000.2, "Operation of the Defense Acquisition System," 12 May 2003.

Figure 3. Defense Acquisition Management Framework

While value engineering is applicable at any point in the life cycle, Figure 4 shows that the savings potential commonly decreases as the program ages. VE should be applied as early as possible in the life cycle. Early VE tends to produce greater savings (or cost avoidance) because at the Design Readiness Review, approximately 80 percent of the costs are committed.[7] Therefore, greater opportunities exist for change and the changes cost less to implement before then.

Even if early opportunities are missed, VE can still be applied. Late in a program VE is precluded only in those rare instances where the cost of the VE effort and subsequent implementation would be greater than the savings potential. While later VE normally adds implementation costs and affects smaller quantities, such deterrents are typically offset by improved performance and reliability through advances in technology and savings generated from increased product life. Usually some opportunities offer net savings at any stage of a program.

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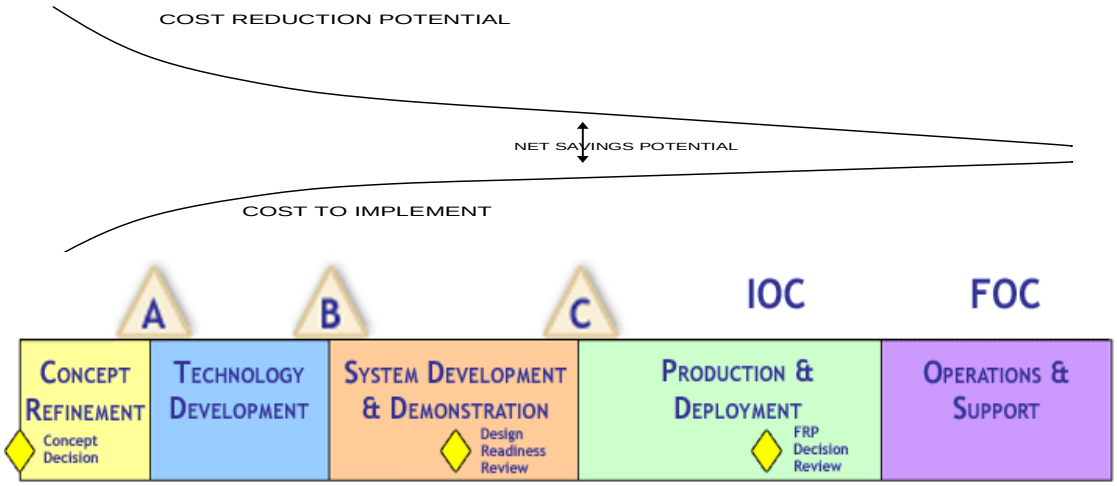
7 Typically only 20 percent of the costs have been incurred.



Source: Adapted from E. D. Heller, General Dynamics Corporation.

Figure 4. VE Savings Potential During the Life of a Typical System

DoD Directive 5000.1 encourages cost savings: "Acquisition programs shall be managed though the application of a systems engineering approach that optimizes total system performance and minimizes total ownership costs."[8] The use of VE and the value methodology can make valuable contributions to the systems engineering process throughout the life cycle, although the most appropriate time to apply VE varies. When to apply VE depends on whether:

- Current system performance or cost does not satisfy the customer;
- Advances in technology have system application, resulting in enhanced performance or reduced cost;
- The likely savings are high; or
- VE may be applied easily.

An important precursor for applying the VE methodology is properly establishing separate cost and income baselines and accumulation practices. This enables more accurate tracking of savings during execution. The following sections describe VE opportunities early in the life cycle, during production and deployment, and during operations and support.

8 DoD Directive 5000.1, Paragraph E1.27.

B. VE EARLY IN THE LIFE CYCLE

The most opportune time to apply the VE methodology is early in the life cycle, *before* production begins, *before* field or technical manuals are drafted, and *before* logistic support plans are finalized. Some of the more important benefits are as follows:

- Savings can be applied to all production units.
- Reductions to the high cost of development, the subsequent cost of production, and the consequent costs related to operation and support may be realized.
- Fewer modifications to production lines, tooling, processes, and procedures will be required.
- Fewer drawing changes will be necessary.
- Fewer post-production changes to logistic and support elements such as manuals, maintenance facilities, and spare parts requirements will be needed.

The Concept Refinement, Technology Development, and System Development and Demonstration Phases encompass the early part of the life cycle.

1. VE During Concept Refinement

Concept Refinement begins with the approval of an Initial Capabilities Document, which identifies the needed capability. Alternative concepts for attaining the needed capability have also been developed, and a plan for an Analysis of Alternatives has been approved. The purposes of Concept Refinement are to refine the initial concepts so that a decision on the preferred system concept can be made and to develop a Technology Development Strategy for the preferred system concept. Concept Refinement presents the first substantial opportunity to influence system design by balancing technology opportunities, schedule constraints, funding availability, performance parameters, and operational requirements.

During Concept Refinement, systems engineering provides top-level, iterative, and recursive analytical processes for each alternative system concept. These processes can result in a technical evaluation of the operational effectiveness and estimated life-cycle costs of the alternative system concepts that may provide a materiel solution to a needed mission capability. Trade-offs among system operational requirements, operational utility, technology maturity, and life-cycle costs lead to a best system solution within allowed constraints. Effectively employing systems engineering will also support a preliminary assessment of the technical and management risk that will be considered in

choosing the preferred system concept and formulating the Technology Development Strategy.

VE can have a significant role in the systems engineering activities during Concept Refinement. The Analysis of Alternatives and associated cost-effectiveness studies[9] can use VE to analytically evaluate functions and provide a mechanism to analyze the essential requirements and develop possible alternatives offering improved value. In this context, detailed evaluations of the technical requirements of each alternative concept are made and their effects on total performance determined. Concurrently, the effect on system concept life-cycle cost of each alternative being considered is estimated and related to the individual technical requirements. Areas of high cost and high-cost sensitivity are identified, and the associated requirement is examined in relation to its contribution to system concept effectiveness. The requirements identified by these high-cost areas are examined in detail from a cost-effectiveness standpoint. Based on these efforts, the VE function is used to do the following:

- Constructively challenge the stated needs and recommend alternatives,
- Constructively challenge the desired mission performance envelopes to ensure they are necessary and most cost effective, and
- Ensure that user requirements are well founded.

After developing advantages and disadvantages of the alternatives under consideration, recommendations on a preferred system concept can be developed.

2. VE During Technology Development

A successful Milestone A decision initiates the Technology Development Phase. This phase reduces technology risk and determines the appropriate set of critical subsystem technologies to be integrated into a full system. Technology development is a continuous technology discovery and development process that reflects close collaboration between the science and technology community, the user, and the developer. Technology development is an iterative process of assessing technologies and refining user performance parameters. At the end of the Technology Development Phase, all critical technologies should have been demonstrated in a relevant environment at the system, subsystem, or prototype level.

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9 Emerson N. Wells, "Cost Effectiveness and Value Engineering: A Comparative Analysis," *SAVE International Annual Conference Proceedings*, Volume III, Atlanta, Georgia, 15–17 April 1968, pp. 47–55.

During technology development, systems engineering provides comprehensive, iterative processes to mature the suite of technologies for the preferred system solution by:

- Converting critical capabilities into subsystem performance specifications;
- Translating user-defined performance parameters into configured subsystems;
- Integrating the technical inputs of the entire design team;
- Managing interfaces;
- Characterizing and managing technical risk;
- Transitioning technology from the technology base into program-specific efforts; and
- Verifying that preliminary designs meet operational needs.

VE can be used to analyze the value of each requirement and the specifications derived from it by comparing function, cost, and worth. By critically examining the cost consequences of requirements and specifications, a VE study can generate answers to the following questions:

- Is the resultant cost effect of each requirement comparable to the worth gained?
- Is the resultant cost effect of the tolerance specified on each requirement comparable to the worth gained?
- Is its resultant cost effect upon the product comparable to the worth gained by the specification?
- Can the specification be tailored to minimize effort and cost?

Such an analysis can help determine whether user requirements and specifications are well founded and also lead to their relaxation or elimination.

3. VE During System Development and Demonstration

Formal program initiation usually occurs when the Milestone Decision Authority approves entrance into the System Development and Demonstration Phase. In this phase, the program, system architectures, and system elements down to the configuration item level are defined based on the technology matured during the Technology Development Phase. System design requirements and the support concept are refined and integration and manufacturing risk are reduced.

The System Development and Demonstration Phase is divided into two parts: System Integration and System Demonstration. During System Integration, systems engineering reduces program risk, identifies potential management issues, and guides

design choices by allocating requirements at greater levels of detail. Through the use of systems engineering, the System Demonstration effort demonstrates the system performance in its intended environment. Verification at each step confirms that specified requirements have been fulfilled. Validation at the end of the process confirms that the refined concept meets the needs of the user.

As part of the development and refinement of the functional architecture, VE should be used for

- Identifying the necessary top-level functions for each of the missions considered,
- Identifying technical approaches (i.e., design concept) to the missions,
- Identifying necessary lower level functions for each technical approach (the value engineer should place emphasis on eliminating unnecessary design restrictive requirements),
- Evaluating each function in terms of technical feasibility, and
- Estimating the cost of various functions.

An effective application of the VE methodology will include further analysis of the high-cost functions and the identification of alternative, less costly ways of achieving the same result. When programs view life-cycle cost as an independent variable (CAIV), it should be treated as equally important to performance and schedule in program decisions. Program managers are encouraged to develop a formal CAIV plan as part of their acquisition strategy, which is required at Milestone B. While the implementation steps in a CAIV plan will depend on the type of system and its current stage in the acquisition framework, two of the suggested elements, cost goals and trade-off studies, tie closely to VE.[10]

Cost Goals. The CAIV plan would include cost goals for unit production cost and O&S costs. The unit production cost goal typically would be established for a specified quantity of systems and a specified peak production rate. The O&S cost goal typically would be an annual cost per deployable unit (e.g., battalion or squadron) or individual system (e.g., ship or missile). The goals should be challenging but realistically achievable.

Trade-off Studies. Cost, schedule, and performance may be traded off within the trade space between thresholds and objectives documented in the capability development

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[10] See "Defense Acquisition Guidebook," Section 3.2.4, Cost As an Independent Variable, 17 October 2004.

document. Over time, as the system design matures, the trade studies become more refined and specialized.

As part of the definition and refinement of the physical architecture (design), VE should support the system engineering process by helping develop alternative ways of providing the required function with lower production and sustainment costs. The value engineer usually engages in such activities in high leverage areas. Therefore, the VE process should first identify individual high-cost subsystems or items to stimulate early detection of unnecessary costs in time to take corrective action. Once these high-leverage areas have been determined, the next step is to shape and evaluate alternative designs in relation to the technical requirements, performance limits, subsystem interrelationships, logistics support requirements, and system cost and value. VE contributes to the Logistics Support Analysis as it is used to establish maintenance plans and to ensure that the design process incorporates logistic requirements and cost considerations, including reliability, maintainability, spares, and obsolescence.

Common VE activities include the following:

- Evaluating design concepts from a life-cycle cost standpoint,
- Eliminating unnecessary design-restrictive requirements established by the user or design community,
- Achieving CAIV,
- Meeting system requirements at the lowest life-cycle cost from a Logistics Support Analysis perspective,
- Searching for new manufacturing processes or new materials to be used in the design,
- Searching for problems encountered by others who attempted to design similar systems or components,
- Defining interfaces between or among functional areas, and
- Conducting design trades.

During the system demonstration (or build and test) step, VE challenges the need for expenditures on data, number of prototypes, peculiar support equipment, and so on. Initial prototypes are evaluated to identify additional opportunities to improve value. VE efforts at this stage analyze how suppliers can help reduce costs, asking the following questions:

- Have suggestions been invited from prospective suppliers regarding possible value improvement from loosening specification requirements?
- Have all nonstandard parts been identified and approved?

- Can the use of each nonstandard part be adequately justified?
- Can a redesign replace a nonstandard part with a standard part?
- Are the standard circuits, standard components, and standard hardware the lowest cost items that will supply the minimum required characteristics?

Once models and prototypes are built, they must be verified to meet the requirements. VE also supports this testing process by:

- Identifying functions to be tested;
- Challenging the need for certain tests, based on the functions the tests are designed to serve;
- Challenging the tolerances of the tests specified, based on the functions the tests are designed to serve; and
- Determining cost-effective ways to test them.

Finally, as a result of the testing experience, the VE process should look for opportunities to simplify the design for operational use—make the system easier to operate and maintain. Once production begins and the system is fielded, it becomes much more expensive to make these kinds of changes.

C. VE DURING PRODUCTION AND DEPLOYMENT

The Production and Deployment Phase begins at Milestone C. During this phase, the system achieves operational capability to satisfy mission needs. As the integrated components develop into a system, the test and evaluation processes frequently reveal issues that require system improvements or redesign. When the testing environment more closely resembles actual field conditions, the required improvements might be complex and subtle. The initial manufacturing process may also reveal unanticipated problems that may be resolved by changing the product somewhat. Low-Rate Initial Production should result in completion of manufacturing development. Full-Rate Production delivers the fully funded quantity of systems and supporting materiel and services for the program or increment.

Systems engineering in the Production and Deployment Phase is primarily concerned with analyzing known deficiencies and determining corrective actions. A plan to build, modify, verify, and test the proposed solution is also formulated and approved. The proposed solution to the deficiency is translated to the appropriate hardware, software, or specification changes. Modifications are created, incorporated, and verified in accordance with the approved plan. This product change may include retrofit, since the

production process has begun. The impact on system cost, schedules, and performance should also be considered when addressing production incorporation.

VE contributes to these systems engineering activities by devising alternative means for achieving required functions and developing alternative designs to meet functional needs. VE has been extensively applied to evaluate and improve manufacturing processes, methods, and materials. These include support equipment, technical data, and facilities, as well as the supply, transportation and handling, maintenance, and training functions. VE projects can be undertaken under certain circumstances:

- Recent developments indicate a potential opportunity for cost reduction;
- The future use of the item depends on significant reduction in production costs; and
- New manufacturing technology and new materials become available.

In addition, as production becomes more mature, VE may support the decision to eliminate quality assurance testing, which often cannot be proposed until considerable experience is acquired and data gathered to prove that it is feasible. VE may also reveal that management reports required to understand a complex situation early in production may turn out to be unnecessary after more experience is gained.

D. VE DURING OPERATIONS AND SUPPORT

During the O&S Phase of the acquisition framework, system support is provided to satisfy operational requirements and sustainment needs in the most cost-effective manner over the life cycle. Usage data are collected and analyzed to determine the root cause of any problems encountered. After a risk assessment is conducted, corrective actions are formulated.

In this phase, systems engineering processes support in-service reviews; trade studies; and decisions made about modifications, upgrades, and future increments of the system. Interoperability or technology improvements, parts or manufacturing obsolescence, aging issues, premature failures, changes in fuel or lubricants, Joint or service commonality, and so on may all indicate the need for system upgrade. System disposal is not a systems engineering activity, but systems engineering processes that inject disposal requirements and considerations into the earlier design processes ultimately affect disposal.

After fielding, opportunities for VE may exist for a long time. Product life cycles are being extended; for consumables, there is no sure way to determine the total quantity that will be purchased. Also, in the past, many items that entered the defense inventory were never subjected to a VE analysis. The potential for VE savings on these items is real. Advances in technology or changes in user requirements provide a basis for potential savings.

After a system or item is fielded, changes are often expensive to implement. Large potential savings to operation, maintenance, and other logistics functions might justify the investment, however. Using VE principles supports the development, evaluation, and implementation of such changes within the overall systems engineering process. Within the Defense Department, the following process has been proven to be a successful context for VE:

1. Establish cost consciousness in the program
2. Establish a cost baseline and identify cost drivers
3. Develop a cost-reduction strategy
4. Manage cost within the program
5. Establish cost goals, objective, and threshold
    a. Establish meaningful cost-reduction metrics
    b. Identify and quantify cost-reduction initiatives
    c. Track implementation of cost-reduction projects
    d. Measure results against the plan

VE contributes to every aspect of that process; it is especially suited to the identification and evaluation of cost-reduction initiatives. The evaluation function is extremely important because such initiatives typically include an up-front investment that will be recouped over time.

VE has been used to formulate initiatives to:

- Extend item life by applying state-of-the-art designs, materials, or processes;
- Reduce repair costs by achieving the repair function in a more economical manner;
- Reduce packaging costs by improving packaging procedures or materials;
- Remanufacture and replace legacy systems;
- Improve reliability and maintainability;
- Use commercial processes, technologies, and commercial off-the-shelf items to reduce cost and improve reliability;

- Replace aging engines and engine parts;
- Improve supply-chain response time and reduce logistics footprint using Direct Vendor Delivery, Commercial Maintenance Agreements, and Virtual Prime Vendor support;
- Initiate reliability-centered maintenance and condition-based maintenance to reduce preventive maintenance costs without affecting corrective maintenance needs;
- Reduce the number of people required to operate and maintain by improving usability and maintainability; and
- Eliminate sole-source procurement.

E. CONCLUDING COMMENTS

A detailed understanding of the acquisition management framework is not a prerequisite for applying VE. It is presented here to describe how VE is likely to be applied throughout a system's life cycle and to emphasize that the earlier VE is applied, the greater the potential for savings. A common misconception is that VE applies only to production contracts. Whenever a new development contract is awarded, the contractor's systems engineering process leads to trade-offs to meet the cost and schedule requirements of the contract. Even under circumstances with exceptionally low risk, a parallel effort to investigate using an alternative (emerging) technology that is expected to perform better at less cost is usually not possible because of constraints on time or resources. VE is an effective mechanism for funding such parallel efforts, as long as the Government is satisfied that the original solution was the best available at that time. Finally, in today's acquisition environment, many systems remain in inventory for a long time because of major modifications or upgrades (e.g., block changes or preplanned product improvements). Therefore, opportunities for large VE savings extend much later into the life cycle.

IV. INTRODUCTION TO THE VE METHODOLOGY

This chapter provides an introduction to the value methodology (or job plan) as it is used to develop recommendations and implement solutions for an identified problem area. Section A summarizes the job plan phases. Because working with people is a large component of the value methodology, understanding the social dynamics problems that may be encountered in a VE project is important. Section B discusses some of these problems and offers potential solutions. Proper project selection is also critical to the success of the VE study; Section C illustrates how the job plan may be used solely within that context.

A. JOB PLAN SUMMARY

The VE job plan can be applied to any subject. It is a mechanism for guiding a study from inception to conclusion. By adhering to certain formalities, the VE job plan ensures that consideration is given to all necessary facets of the problem.

The VE job plan breaks out the task being studied into functions. It provides time for the essential creative work and its necessary analysis so that the best choices can be made for further development. The job plan leads to the establishment of an effective program aimed at the selection of best value alternatives. It concludes with specific recommendations, the necessary data supporting them, a list of implementing actions, a proposed implementation schedule, and a required follow-up procedure.

The job plan is normally organized by a value team leader. It is typically conducted in eight sequential phases (which may overlap in practice):[11]

1. Orientation Phase
2. Information Phase
3. Function Analysis Phase
4. Creative Phase
5. Evaluation Phase
6. Development Phase

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[11] The structure of the job plan is adapted from *Value Methodology Standard*, SAVE International, October 1998. The Society of American Value Engineers (SAVE) International is devoted to the advancement and promotion of the value methodology. Information can be found at http://www.value-eng.org/.

7. Presentation Phase
8. Implementation Phase

The Orientation Phase is conducted to prepare for the value analysis. This phase, which may last several weeks, lays the groundwork for an efficient and productive study by refining the problem statement, collecting much of the data needed, and organizing for the efforts to follow.

The value study comprises Phases 2 through 7 of the job plan. The more analytical steps in the value methodology, the phases typically performed in a workshop setting involving all stakeholders. Systematic pursuit of the methodologies within these phases leads to recommendations for improving the existing situation and thereby increasing value for everyone involved. They conclude with a presentation of recommendations for improvement to the decision-maker.

The Implementation Phase occurs after the value study is over and decisions have been made. It monitors the approval process and implementation of the action plan. The name of the phase may be slightly misleading. Project approval is normally not given solely on the basis of the brief presentation that occurs at the conclusion of the workshop. Approval will usually be obtained after the completion of follow-up actions such as providing more data and meeting with others. Implementation itself begins after the final approval is granted.

Figure 5 depicts each phase of the job plan. It lists the questions that each phase is designed to answer and identifies the activities performed. This chart is discussed in detail in Chapter V, where each phase is described.

Although the job plan divides the study into a distinct set of work elements, judgment is necessary to determine the depth to which each phase is performed as a function of the resources available and the results expected. The VE program in the Defense Department does not necessarily use all the steps of the job plan. In fact, the only requirement for the Government is that a change made to improve the value (i.e., performance and/or cost) of a required function be based on a function analysis to determine the best value. For example, an activity supporting the DoD Component Breakout, Competition, or Spares Management initiatives may be a relevant use of VE. From a contractor perspective, any analysis leading to an approved VECP is applicable.[12]

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[12] Department of Defense Inspector General, "DoD IG Issue Resolution Agreement: Defining Value Engineering (VE) for Reporting Purposes," 22 November 2000.

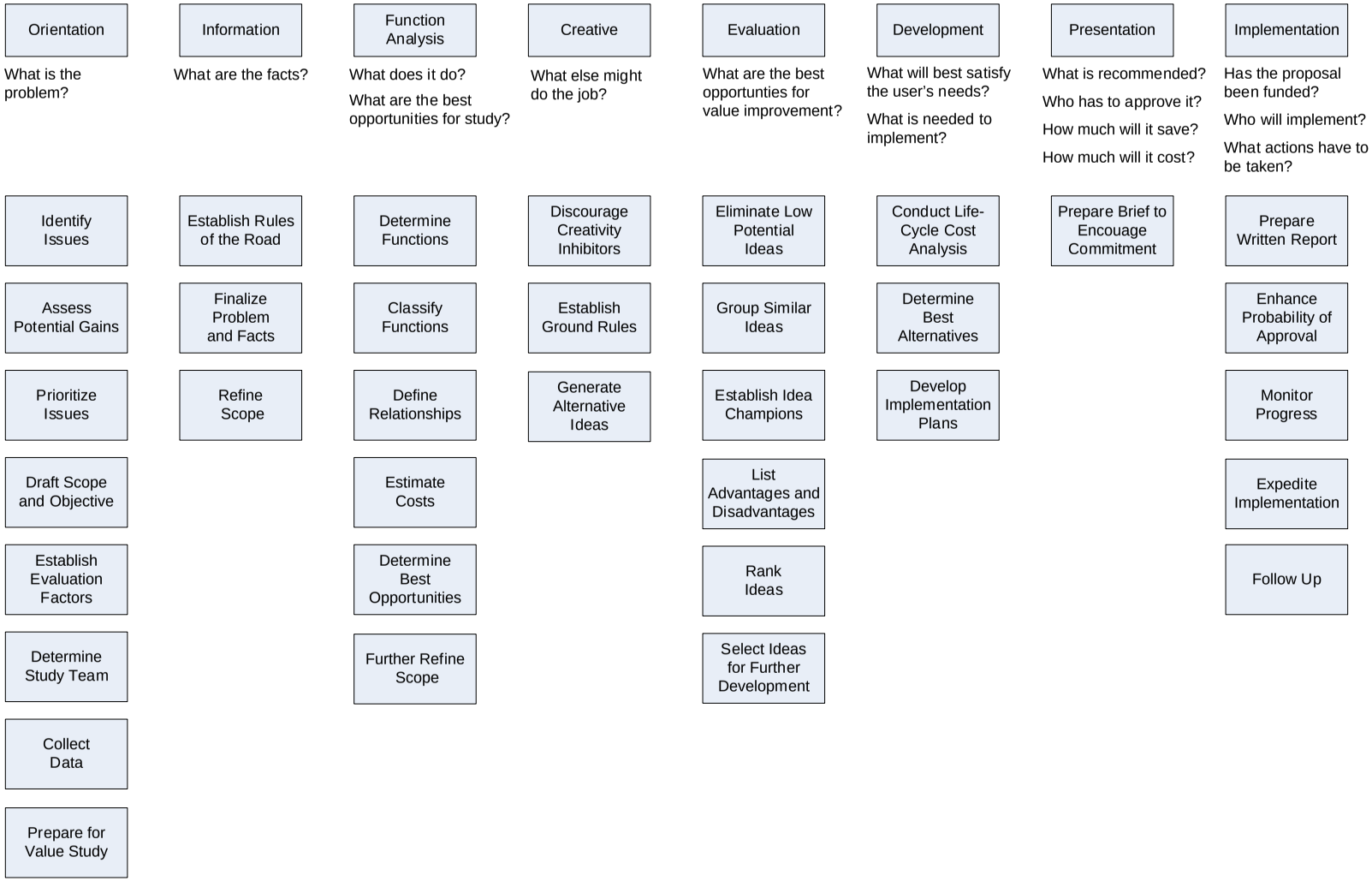

Figure 5. Job Plan

B. PREPARING FOR THE SOCIAL DYNAMICS IN A VE STUDY

The concept of teaming has always been important in value engineering. In the 1980s, businesses began to look for improved ways of developing products to reduce the amount of "rework" necessary and to shorten the cycle time needed to get products to market. They began by using organized cross-functional teams comprising the various disciplines involved and gave the teams authority to develop the entire product. This change was important because when expertise resides in separate parts of the organization, all aspects of the effort are generally conducted sequentially. For example, a requirement for a new product might start with a concept group, then be given to a design group, a test group, and finally to a manufacturing group before the product ever gets to market. If the design group provides a prototype to the test group and they discover flaws in the details, it must be sent back to the design group for alteration resulting in delays and duplicative effort. Using cross-functional teams, on the other hand, means that expertise from various disciplines is used in a single organization with full authority to design, develop, test, manufacture, and deliver a product. Today, the concept of teaming has become the way leading-edge firms in the private sector and in Federal agencies perform many multi-disciplined projects.

Consequently, a prime factor in the success or failure of a study is how VE team members conduct themselves in various situations:

- Contacts between members of the VE study group and their sources of information (e.g., design engineers, estimators, and users),
- Relations within the VE study group, and
- Contacts with persons who have the authority to approve or disapprove the changes recommended by the VE team.

"People problems" are sometimes more difficult to resolve than technical problems. Many of the people problems encountered in a VE study are motivated by a resistance to change. In the VE context, Parker defines "roadblock" as "a decision, attitude, or situation which inhibits progress."[13] Roadblocks are natural hazards to the benefits that would flow from VE changes, and both VE practitioners and managers must be able to effectively deal with them. Any change can meet resistance. Understanding why roadblocks occur and responding diplomatically with the facts will go a long way toward developing a solution. Roadblocks or resistance to change have many sources:

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[13] Donald E. Parker, *Value Engineering Theory*, The Lawrence D. Miles Value Foundation, Washington, D.C., 1998, revised edition, p. 56.

- If the nature and effect of a proposed change are not clearly explained, and understood, it may be considered a threat. Incomplete information produces insecurity, and insecurity can turn to hostility.
- Different people interpret proposals in different ways, particularly if the suggestions are vague and not buttressed by adequate facts.
- When pressure both for and against change are intense, resistance grows, ultimately immobilizing everyone.
- The less opportunity a person has to express views about a proposed change, the greater the resistance to it.
- Proposals that are made on a personal basis, or that reflect on an individual's ability or performance, produce hostility.
- Strong resistance can be expected if a change will alter long-established institutions, habits, or customs.

Roadblocks can be easily recognized. In their most common form, they take shape as verbal barriers, either objective or emotional. These verbal barriers are then followed by a lack of cooperation. In the minds of people using them, roadblocks are self-justifying and do not require further explanation.

For a VE project to be successful, people from all levels in an organization must cooperate to develop a dynamic and creative spirit. Favorable attitudes toward and acceptance of a new concept are based upon positive individual experiences building upon one another over a period of time. Team members can use the following general principles of social behavior, adapted from Parker,[14] to promote cooperation in overcoming roadblocks and thereby gaining enthusiastic acceptance of VE:

- *Avoid blame for the current situation.* Something deemed of poor value today may not have been deemed as such when the decision to pursue it was made. The reasons for poor value are many, but the stigma attached to it can be minimized by understanding some of its causes, such as lack of information or time, habitual thinking, negative attitudes, reluctance to seek advice, improved technology, lack of understanding of real requirements, and lack of yardsticks for measuring value.
- *Maintain openness throughout the project.* Acquaint people with the nature and objectives of the project. Make suggestions, recommendations, and requests clear at all times. Make the report clear and accurate. Always have facts to back up the proposal, and be prepared to present them clearly.

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[14] Ibid., pp. 49–63.

- *Avoid displaying a superior attitude.* The VE team member seeking information and assistance should honestly admit unfamiliarity with the item or project under study and should express appreciation for help provided. Show respect for another person's opinions. Never criticize or belittle a person's work on an item under study.
- *Be respectful.* Respect the chain of authority, customs of the organizations, and personalities of the people involved.
- *Maintain flexibility.* Put yourself in the position of the other person to ascertain the answers to the following questions: What do they say? What do their actions indicate? What do they really believe? Why do they believe this way, act as they do, or say what they say? Objectively select a workable approach to whatever attitude is encountered.
- *Consult with those affected by proposed changes.* Present proposals objectively and courteously. Avoid implied criticism. Anticipate the impacts on the particular individual and assess their potential reactions in advance. Listen to what they say and respond to their thoughts and needs. Continued objections to a proposal may be clues to modifications necessary to facilitate approval.
- *Make everyone part of the solution.* Give broad credit for contributions to a successful VE study. Convince all people involved that their competencies are recognized and essential to the success of VE studies and changes. Promote VE as a team effort of the entire organization.
- *Think positively.* Positive thinking has been suggested as an effective means of overcoming the natural fear of change.

Having a favorable setting and an effective facilitator for the value study helps relieve potential social dynamics problems. Holding the workshop away from the regular work environment is preferable because it:

- Ensures the full attention of the team throughout the scheduled study;
- Establishes a neutral setting where no stakeholder element can be perceived to have an advantage over another element;
- Creates a relaxed climate for communication;
- Reduces distractions; and
- Maintains focus and momentum.

The workshop is led by a facilitator typically not the team leader. During a workshop, the facilitator should be able to contribute to all phases of the job plan as

necessary without dominating the process. In the workshop context, the facilitator is responsible for:

- Presenting the problem at the start of the workshop;
- Keeping the team focused on the specific topic;
- Keeping all team members involved in the discussion and the work that needs to be done;
- Keeping the team moving and motivated;
- Leading the team effectively by delegating responsibilities as appropriate, maintaining neutrality, and being diplomatic;
- Maintaining enthusiasm for the VE process; and
- Communicating with the study sponsor.

The benefits of the VE methodology may be diminished in practice if the facilitator cannot deal effectively with difficult people on the team. Cook[15] discusses some of the top difficulties reported anecdotally for facilitators and suggests techniques for dealing with such situations.

C. USING THE VALUE METHODOLOGY TO DETERMINE THE RIGHT PROBLEM TO ATTACK

In some cases, defining the "right problem" can be a labor-intensive, time-consuming, and difficult task, and there is no guarantee that the result will be the best opportunity for value improvement. The value methodology itself can be applied to refine the problem-definition process, reduce the workload, and provide a greater likelihood of success.

Greenfield[16] describes a process for applying the value methodology to develop a new design concept (i.e., the "right project") rather than the traditional use of VE to optimize an existing design. VE techniques are iteratively inserted into the planning process to select a concept that delivers the optimum life-cycle cost. The following example illustrates how the job plan might be used in the broader problem-definition context.

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15 Rae Gordon Cook, "Tactics for Tough Facilitations: Dealing with Difficult People and Going International," *SAVE International Annual Conference Proceedings,* Volume XXXIII, Washington, D.C., 14–17 June 1998, pp. 56–64.

16 Howard Greenfield, "Integrating VE in Project Planning," *SAVE International 44th Annual Conference Proceedings*, Montreal, Quebec, 12–15 July 2004.

Assume that a weapon system program manager is faced with high O&S costs that are diverting resources from important modernization needs. The program manager decides to use the value methodology to solve this problem by determining those O&S cost elements that are best addressed in greater detail. Table 1 shows the expected accomplishments in each phase of the problem definition job plan.

Table 1. Accomplishments by Job Plan Phase

Job Plan Phase	Accomplishment
Information Phase	Identify key cost drivers
Function Analysis Phase	Determine the high-level basic functions for each of the key cost drivers
Creative Phase	Generate ideas for strategies/approaches for attacking the functions that offer the greatest opportunity for value improvement
Evaluation Phase	Evaluate the alternative opportunities for value improvement for each of the key cost drivers
Development Phase	Refine the alternatives further, showing strengths and weaknesses
Presentation Phase	Show recommendations for further analysis to the study sponsor
Implementation Phase	Conduct a value study on the cost drivers selected for further analysis

Greenfield suggests that his process has the following advantages:

- Obtains early consensus on requirements to be fulfilled by the project,
- Allows groups with different interests and backgrounds to focus on the requirements of the specific project,
- Allows tough decisions to be made efficiently and promotes buy-in from stakeholders, and
- Reduces the time required to obtain the optimal solution considering a multitude of issues to resolve.

These advantages equally apply when using the value methodology to help identify the right problem to be addressed.

D. CONCLUDING COMMENTS

The VE job plan can be applied to any subject. It is a mechanism for guiding a study from inception to conclusion. By adhering to certain formalities, the VE job plan ensures that consideration is given to all necessary facets of the problem. Although the job plan divides the study into a distinct set of work elements, judgment is necessary to

determine the depth to which each phase is performed as a function of the resources available, the results expected, and the people involved (often the most important determinant).

V. THE VE METHODOLOGY IN DETAIL

Each phase of the job plan introduced in Chapter IV and summarized in Figure 5 is described in greater detail in the sections of this chapter.

A. ORIENTATION PHASE

The purpose of the Orientation Phase is to refine the problem and prepare for the value study. Although a problem area may have been identified, the value study or workshop has a far greater likelihood of success if ample preparation time has been devoted to (1) determining what aspects of the problem will be addressed in detail and (2) preparing everything needed for the analysis itself. Throughout these preparatory activities, a close working relationship between the value team leader and the manager sponsoring the project also contributes significantly to a successful outcome.

The following subsections describe the activities that occur during the Orientation Phase. Note that the activities may occur in an order different from that shown here. Some activities may also be repeated or may occur simultaneously if other people are supporting the team leader's efforts.

Note that the first five activities represent one systematic approach to refining the problem. The job plan itself can also be used entirely in the context of the Orientation Phase as a formal project planning tool. This is illustrated in Chapter IV, Section C.

1. Identify the Specific Issues To Be Addressed

The problem area should be divided into its constituent elements. Each element should represent a specific issue that can be addressed and resolved.

Consider the Navy's Standard missile program. The program office found itself in a situation where missile demand was level, but the price was increasing while budgets were decreasing. Of the three controllable constituent elements of missile cost (production, development, and logistics), production costs were determined to be the most fruitful area for further investigation, primarily because trade-offs could be made between cost and performance. In fact, the production costs could readily be broken

down into smaller and smaller constituent elements to form the basis of individual VE projects.[17]

Identifying such specific issues is accomplished by developing an understanding of the sponsor's problems and avoiding areas that the sponsor would not be able change because of political, cultural, or feasibility implications. Once the problems are understood, they can be addressed at varying levels of detail. At this stage of the value methodology, enough detail is needed to obtain a general grasp of potential VE projects.

2. Assess the Potential Gains for Resolving Each of These Issues

The purpose of this activity is to identify issues that have the greatest potential for value improvement. Solution areas postulated this early in the process should be used for this purpose only. Such solutions should not inhibit creative activities applied later in the job plan to generate alternatives.

The assessment of the potential gains for resolving issues should be as quantitative as possible; however, at this stage of the analysis, estimates will be crude. While it may not be too difficult to develop a reasonable understanding of the costs involved, savings estimates are much more problematical since no solution has been developed. Some information is normally available, however.

In the Standard Missile example, one of the VE projects involved the transceiver assembly. One potential solution was replacing the assembly with a less costly one. Savings estimates were very difficult since the characteristics of the new assembly were unknown. Another potential solution involved developing a higher component level of aggregation. Here, savings would be generated by eliminating tests.

3. Prioritize the Issues

While prioritization should take into account the potential gains, it should also consider the likelihood of determining an effective solution and the feasibility of implementing that solution. In the case of the transceiver assembly for the Standard missile, the second potential solution, developing a higher component level of aggregation, was much more straightforward and had a higher likelihood of success than replacing the assembly with one less costly, the first potential solution.

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[17] See Roland Blocksom, "STANDARD Missile Value Engineering (VE) Program—A Best Practices Role Model," *Defense AT&L Magazine*, July-August 2004, pp. 41–45.

Understanding the importance of the problem to the project sponsor is also a key factor. If the sponsor is determined to solve the problem, the likelihood of success is enhanced. Once management commitment is understood, it is useful to ask why a problem has not been solved before.

The answer to this question may identify roadblocks to be overcome. Knowing what stands in the way of a solution is another important feasibility consideration that should enter into the prioritization process. Finally, other benefits such as performance improvement should also be taken into account.

4. Draft a Scope and Objective for the Value Study

The study team's efficiency is significantly enhanced when limits are established in advance. More than one of the constituent problem elements may be included in the scope. The scope must be approved by the study sponsor. Ultimately, the scope and objective will be finalized in the Information Phase. This preliminary work will expedite that process.

5. Establish Evaluation Factors

Targets for improvement should be challenging, and evaluation factors must be measurable. They determine the relative importance of the ideas and potential solutions generated by the team. Both improvement targets and evaluation factors must be approved by the study sponsor.[18]

6. Determine Team Composition

Essential characteristics for team members include technical or functional expertise, problem-solving and decision-making ability, and interpersonal skills. Participants should be team players who are willing to share responsibilities and accountability while working together toward a common objective. The team should also be multidisciplinary and include all factions affected by the study to ensure that relevant stakeholders and experts are included. Kaufman suggests that because gathering all the information needed

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[18] In manufacturing-oriented workshops, criteria are not usually selected until competing alternatives are developed.

to make a "no-risk decision" is impossible, a multidisciplinary team should provide enough different perspectives to at least substantially reduce the risk.[19]

The team should ideally have no more than 12 participants. After the team members have been selected, the team leader should prepare a management memorandum to be sent to all team members to:

- Emphasize the importance of their role,
- Approve the necessary time commitment,
- Authorize sharing of any objective and subjective data that bear on the problem, and
- Identify the team leader.

7. Collect Data

The team leader organizes the data-collection activities in advance of the workshop. As more information is brought to bear on the problem, the probability of substantial benefit increases. To increase the study team's productivity, collect as much data as possible in advance. It is often beneficial to involve the entire team in the data-collection effort. Some team members may have key information readily available to them.

The data should be as tangible and quantitative as possible; they should include anything potentially useful for (1) understanding the problem, (2) developing solutions, and (3) evaluating pros and cons of the solutions. The paramount considerations are getting enough facts and getting them from reliable sources.

In addition to possessing specific knowledge of the item or process under study, it is important to have all available information concerning the technologies involved and to be aware of the latest technical developments pertinent to the subject being reviewed.

Developing alternative solutions and ranking them depend on having cost data. Data on customer and user attitudes also play a key role. Part of the VE study is aimed at identifying which aspect of the task holds the greatest potential for payoff. This potential for payoff is a function of the importance to the user and customer. The seriousness of user-perceived faults is also a factor in prioritization.

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[19] J. Jerry Kaufman, "Value Engineering for the Practitioner," North Carolina State University, 1990, pp. 2-3 and 2-4.

8. Prepare Logistically for the Value Study

The value study facilitator, who may also be the team leader, is responsible for preparing the team to participate in the value study. Initially, brief meetings with potential team members may be held to determine who should participate. The team leader/facilitator should:

- Ensure participants know what data they should bring,
- Set up study facilities and prepare materials (easels, markers, etc.),
- Set up kickoff briefing and results briefing with management, and
- Obtain an example of a study item for the team to use.

Pre-study reading materials should be identified and distributed to participants. Documents that may be assigned as advanced reading include the agenda, operational requirements documents, design documents, performance requirements, production quantities, inventory data, failure/quality information, and others necessary to ensure consistent understanding of the issues.

It may be useful to schedule a pre-workshop orientation meeting to:

- Review workshop procedures;
- Acquaint people with the problem and the read-ahead material;
- Eliminate incorrect preconceived notions about VE, the job plan, the workshop itself, the problem, the people, and so on;
- Jump-start the team-building process;
- Clarify acceptable and unacceptable behaviors (rules of the road) for team-member participation; and
- Identify additional information needs.

It is a good idea to set the date reasonably far in advance (4 to 6 weeks) to allow personnel to arrange their schedules around the study. When a workshop setting is used, the value study typically takes 3 to 5 days.

B. INFORMATION PHASE

The purpose of the Information Phase is to finalize the scope of the issues to be addressed, targets for improvement, and evaluation factors while building cohesion among team members. In many respects, the Information Phase completes the activities begun in the Orientation Phase. This work is normally carried out in the workshop setting and is therefore usually the first opportunity for all team members to be together.

Consequently, it is important to use the Information Phase to motivate the team to work toward a common goal. Finalizing the scope of the issues to be addressed, targets for improvement, evaluation factors, and data collection are ideal endeavors for building that cohesion. The specific activities are described in the following subsections.

1. Establish Workshop Rules of the Road

This activity is the beginning of the team-building process; the facilitator should ensure that all team members know each other and their relevant backgrounds, authority, and expertise. Some authors (e.g., Stewart) suggest team-building exercises be conducted at the beginning of the Workshop.[20] The following guidelines should be established to set the stage for an effective working relationship among the team members:

- Share workload equally whenever possible.
- Be willing to admit that you do not know something, but strive to get the answer. Do not be afraid to make mistakes.
- Stay focused—off tangents—and follow the basic problem-solving steps. Do not waste time discussing whether or not you should use each step; do it and evaluate it all after you have completed the entire workshop. Be sure you understand the approach and its purpose, including the reason for each step and the technique being applied. Keep the discussions relevant.
- Do the job together as a team. Do not force your solutions, sell them! Remember, there can be more than one solution to a problem.
- Be a good listener; do not cut people off and do not second-guess what other people are about to say and what they are thinking.
- Keep an open mind and do not be a roadblock.
- Be enthusiastic about the project and what it is that you are doing.
- Do not attempt to take over as a team leader; be as helpful as possible. Remember, the leader already has a difficult job in trying to guide, control, and coordinate the overall effort.
- Accept conflicts as necessary and desirable. Do not suppress them or ignore them. Work them through openly as a team.
- Respect individual differences. Do not push each other to conform to central ideas or ways of thinking.
- Work hard. Keep the "team climate" free, open, and supportive.
- Fully use individual and team abilities, knowledge, and experience.

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[20] Robert B. Stewart, "Fundamentals of Value Methodology," Xlibris Corporation, 2005, pp. 113–118.

- Accept and give advice, counsel, and support to each other while recognizing individual accountability and specialization.

2. Finalize the Problem and the Associated Facts

Discuss the problem so that all team members achieve a consistent understanding of the issues at hand. Work on specifics, not generalities. This approach also serves as a useful team-building exercise.

The VE team should have gathered information consistent with the study schedule before the start of the workshop. If possible, obtain physical objects (e.g., parts) that demonstrate the problem. Where supported facts are not obtainable, the opinions of knowledgeable persons may be used. Such people may be invited to participate in the workshop, or their opinions may be documented. The Information Phase is typically used to familiarize the team members with the data and the data sources in the context of defining the problem. The keys are:

- Get up-to-date facts,
- Get facts from the best sources,
- Separate facts from opinion, and
- Question assumptions.

Having all of the pertinent information is the ideal situation, but missing information should not preclude the performance of the VE effort.

Quality Function Deployment is a structured approach to defining customer needs or requirements and translating them into specific plans to produce products or develop processes to meet those needs.[21] Ball suggests that Quality Function Deployment techniques can be beneficial in the Information Phase because a better understanding of customer requirements leads to a better understanding of function.[22]

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21 Adapted from Kenneth Crow, "Customer-Focused Development with QFD," DRM Associates, 2002, available online at http://www.isixsigma.com/offsite.asp?A=Fr&Url=http://www.npd-solutions.com/qfdsteps.html. A variety of additional articles may be found in Robert A. Hunt, ed., "The Leading Edge in Quality Function Deployment," *International Journal of Quality & Reliability Management*, Volume 20, Number 1, 2003.

22 Henry A Ball, "Value Methodology—The Link for Modern Management Improvement Tools," *SAVE International Annual Conference Proceedings*, Volume XXXVIII, Scottsdale, Arizona, 8–11 June 2003.

3. Refine the Scope

The problem at hand often requires more time than the workshop schedule permits. In these cases, it is important to re-scope the problem to ensure that the most important elements are examined during the workshop. Plans for continuing the effort on the balance of the problem can be made at the end of the workshop.

Once the scope is determined and the final set of facts are collected from the best possible sources of data, targets for improvement and evaluation factors should be re-examined and finalized. The study sponsor should approve any changes.

C. FUNCTION ANALYSIS PHASE[23]

The purpose of the function analysis phase is to identify the most beneficial areas for study. The analytical efforts in this phase form the foundation of the job plan. The disciplined use of function analysis is the principal feature that distinguishes the value methodology from other improvement methods. The following subsections describe the activities in the Function Analysis Phase.[24]

1. Determine the Functions

For the product or process under study, this activity encompasses determining 40 to 60 functions that are performed by the product or process itself or by any of the parts or labor operations therein. Functions are defined for every element of the product or process that consumes resources. The functions are typically recorded on adhesive-backed cards for later manipulation.

A function is defined as the natural or characteristic action performed by a product or service.[25] Unstructured attempts to define the function(s) of an item will usually result in several concepts described in many words. Such an approach is not amenable to quantification. In VE, a function must be defined by two words: an active verb and a measurable noun.

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[23] Some material in this section was adapted from information in Army Pamphlet 11-3, "Value Engineering" (undated), and DoD Handbook 4245.8-H, "Value Engineering," March 1986.

[24] These activities are adapted from *Function: Definition and Analysis*, SAVE International, October 1998. They are consistent with those listed in "Value Methodology Standard," SAVE International, October 1998.

[25] "Value Methodology Standard," SAVE International, October 1998.

- The *verb* should answer the question, “What does it do?” For example, it may generate, shoot, detect, emit, protect, or launch. This approach is a radical departure from traditional cost-reduction efforts because it focuses attention on the required action rather than the design. The traditional approaches ask the question, “What is it?” and then concentrate on making the same item less expensive by answering the question, “How do we reduce the cost of this design?”
- The *noun* answers the question, “What does it do this to?” The noun tells what is acted upon, (e.g., electricity, bullets, movement, radiation, facilities, or missiles). It must be measurable or at least understood in measurable terms, since a specific value must be assigned to it during the later evaluation process that relates cost to function.

A measurable noun together with an active verb provides a description of a work function (e.g., generate electricity, shoot bullets, detect movement, etc.). They establish quantitative statements. Functional definitions containing a verb and a non-measurable noun are classified as sell functions. They establish qualitative statements (e.g., improve appearance, decrease effect, increase convenience, etc.). It is important to provide the correct level of function definition. For example, the function of a water service line to a building could be stated as “provide service.” “Service,” not being readily measurable, is not amenable to determining alternatives. On the other hand, if the function of the line was stated as “conduct fluid,” the noun in the definition is measurable, and alternatives dependent upon the amount of fluid being transported can be readily determined.

The system of defining a function in two words, a verb and a noun, is known as two-word abridgment. Advantages of this system are that it:

- Forces conciseness. If a function cannot be defined in two words, insufficient information is known about the problem or too large a segment of the problem is being attempted to be defined.
- Avoids combining functions and defining more than one simple function. By using only two words, the problem is broken down into its simplest element.
- Aids in achieving the broadest level of dissociation from specifics. When only two words are used, the possibility of faulty communication or misunderstanding is reduced to a minimum.
- Focuses on function rather than the item.
- Encourages creativity.
- Frees the mind from specific configurations.
- Enables the determination of unnecessary costs.
- Facilitates comparison.

2. Classify the Functions

The second major activity in the Function Analysis Phase is to group the functions into two categories, basic and secondary.

The basic function is the required reason for the existence of an item or a product, and answers the question, "What must it do?" Basic functions have or use value:

> A basic function is the primary purpose or most important action performed by a product or service. The basic function must always exist, although methods or designs to achieve it may vary.[26]

A product or service may possess more than one basic function. This is determined by considering the user's needs. A non-load-bearing exterior wall might be initially defined by the function description "enclose space." However, further function analysis determines that, for this particular wall, two basic functions more definitive than the above exist; they are "secure area" and "shield interior." Both answer the question: "What does it do?"

Secondary functions answer the question "What else does it do?" Secondary functions are support functions and usually result from the particular design configuration. Generally, secondary functions contribute greatly to cost and may or may not be essential to the performance of the primary function:

> A function that supports the basic function and results from the specific design approach to achieve the basic function. As methods or design approaches to achieve the basic function are changed, secondary functions may also change. There are four kinds of secondary functions:
>
> 1. Required—A secondary function that is essential to support the performance of the basic function under the current design.
> 2. Aesthetic—A secondary function describing esteem value.
> 3. Unwanted—A negative function caused by the method used to achieve the basic function such as the heat generated from lighting which must be cooled.
> 4. Sell—A function that provides primarily esteem value. For marketing studies, it may be the basic function.[27]

Secondary functions that lend esteem value (convenience, user satisfaction, and appearance) are permissible only insofar as they are necessary to permit the design or item to work or sell. Therefore, they sometimes play an important part in the marketing

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[26] Ibid.

[27] Ibid.

or acceptance of a design or product. Value analysis separates costs required for primary function performance from those incurred for secondary functions to eliminate as many non-value-added secondary functions as possible, improve the value of the remaining ones, and still provide the appeal necessary to permit the design to sell.

3. Develop Function Relationships

Two principal techniques have been developed to create a better understanding of functional relationships—a Function Hierarchy Logic model and the Function Analysis System Technique (FAST).[28] This handbook concentrates on the customer-oriented FAST approach and the use of the FAST diagram.[29] FAST was developed by Charles W. Bytheway of the Sperry Rand Corporation and introduced in a paper presented at the 1965 National Conference of the Society of American Value Engineers in Boston. Since then, FAST has been widely used by Government agencies, private firms, and VE consultants. FAST is particularly applicable to a total project, program, or process requiring interrelated steps or a series of actions. The basic customer-oriented FAST steps are briefly described below.

- *Step 1—Determine the task function:* A FAST diagram begins with the basic functions on the top and the secondary functions on the bottom. A task function is "that function which fulfills the overall needs and wants of the user—in other words, is the main reason for the existence of the product or process in the eyes of the customer or user."[30] If the task function is among the basic functions already identified, it should be pulled to the left side of the FAST diagram. If it does not exist, it must be created. Determining the task function is not always an easy process. For instance, the most offered task function for a cigarette lighter is "lights cigarettes." This, however, immediately stumbles over the obvious question, "What about pipes and cigars?" An alternative might then be

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28 These two approaches are described on an overview basis and illustrated using the same project in "Function Relationships—An Overview," SAVE International Monograph (undated).

29 Technical FAST and classical FAST follow different rules and formats. They are more applicable to construction-oriented projects. Additional information about Function Hierarchy Logic model can be found in "Function Logic Models," SAVE International Monograph (undated). The equivalent publication on FAST is "Functional Analysis Systems Techniques—The Basics," SAVE International Monograph (undated). The Army has published some FAST training material, "Function Analysis System Technique (FAST) Student Guide," prepared by Nomura Enterprise, Inc., and J.J. Kaufman Associates, Inc., for the U.S. Army Industrial Engineering Activity, Rock Island, Illinois. The approach outlined in this section most closely follows Theodore C. Fowler, *Value Analysis in Design*, Van Nostrand Reinhold, 1990.

30 Theodore C. Fowler, *Value Analysis in Design*, Van Nostrand Reinhold, 1990, p. 75.

"generates flame." However, the electrical resistance lighter in a car only "emits energy." It becomes apparent that the thought process must focus in either one direction or another to develop a multiplicity of two-word abridgements from which one or more levels may be chosen as the level of the primary functions to be studied.

- *Step 2—Identify the primary basic functions:* Select the basic functions that directly answer the question "How does (the product or process) perform the task function?" If all direct answers are not among the existing basic functions, create a new one. All of these "primary" basic functions are grouped at the top of the first column to the right of the task function.
- *Step 3—Identify the primary supporting functions:* All customer-oriented FAST diagrams contain primary supporting functions that assure dependability, assure convenience, satisfy the user, or attract the user. In the FAST diagram, place all of the primary support functions to the right of the task function, below the primary basic functions.
- *Step 4—Expand the FAST diagram to the right:* Keep asking how (the product or process) does this from the viewpoint of a user. Most answers will be found among the existing functions. Add second, third level, and lesser functions as needed, but don't expand a function unless the "how" question is answered by two or more functions. Both primary basic and primary supporting functions should be expanded in this way. Repeating the "how" question in this way is sometimes called the ladder of abstraction method. It is a thought-forcing process. Because using more than one definition can generate more creative ideas, this approach leads to greater fluency (more ideas), greater flexibility (variety of ideas), and improved function understanding of the problem.
- *Step 5—Verify the FAST diagram:* The FAST diagram (see Figure 6) is verified by driving one's thinking up the ladder of abstraction. Asking "why" raises the level, making the function description more general. In practice, the desired level is one that makes possible the largest number of feasible alternatives. Since the higher levels are more inclusive, affording more opportunities, what is desired is the highest level that includes applicable, achievable alternatives. A practical limit to the "why" direction is the highest level at which the practitioner is able to make changes. If the level selected is too low, alternatives may be restricted to those resembling the existing design. If the level is too high, it may obscure achievable alternatives and suggest alternatives that are beyond the scope of effort.

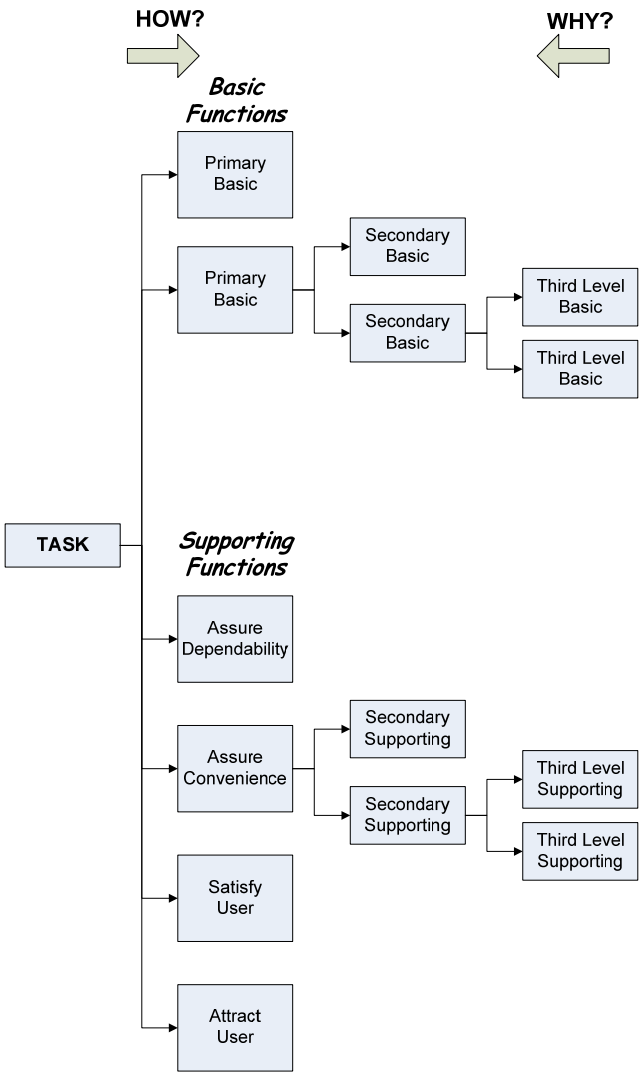

Figure 6. Illustrative Customer-Oriented FAST Diagram

4. Estimate the Cost of Performing Each Function

All VE efforts include some type of economic analysis that is used to identify areas of VE opportunity and provide a monetary base from which the economic impact of the effort can be determined. The prerequisite for any economic analysis is reliable and appropriate cost data. Consequently, the VE effort should use the services of one or more individuals who are skilled in estimating, developing, and analyzing cost data. The cost of the original or present method of performing the function (i.e., the cost for each block of the FAST diagram) is determined as carefully and precisely as possible given the time constraints for preparing the estimate.

The accuracy of a cost estimate for a product depends on the:

- "Maturity" of the item,
- Availability of detailed specifications and drawings, and
- Availability of historical cost data.

Similarly, the accuracy of a cost estimate for a service depends on the:

- People involved;
- Time spent performing the service;
- Waiting time; and
- Direct, indirect, and overhead labor and material costs.

In some cases, a VE study will involve both products and services.

5. Determine the Best Opportunities for Improvement

The objective of this activity is to select functions for continued analyses. This is often accomplished by comparing function worth[31] to function cost, where value is defined by the ratio of worth to cost. Thus function worth helps determine whether the VE effort will be worthwhile and provides a reference point to compare alternatives. It can even be used as a psychological incentive to discourage prematurely stopping the VE effort before all alternatives are considered.

It is usually not necessary to determine the worth of every function. Cost data aid in determining the priority of effort. Because significant savings potential in low-cost areas may not be a worthwhile pursuit, and high-cost areas may be indicative of poor value, the latter are prime candidates for initial function worth determination. Costs are usually distributed in accordance with Pareto's Law of Maldistribution; that is, a few areas, "the significant few," (generally 20 percent or less) represent most (80 percent or more) of the cost. Conversely, 80 percent of the items, "the insignificant many," represent only 20 percent of total costs. Figure 7 illustrates this relationship.

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31 *Function worth* is defined as the lowest cost to perform the function without regard to consequences.

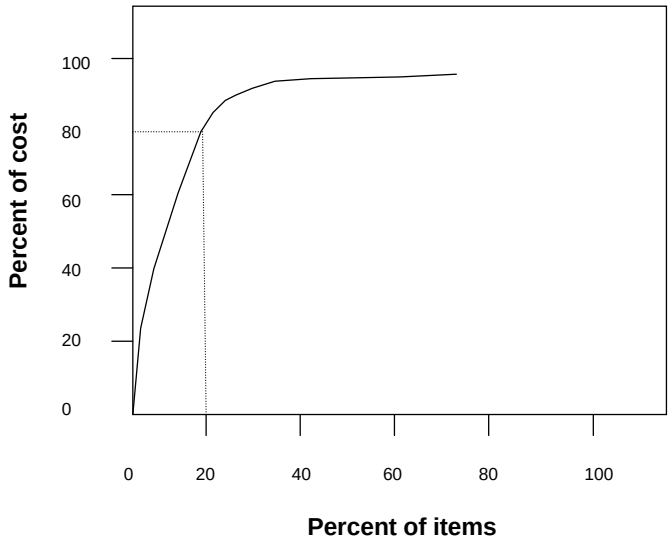

Figure 7. Pareto's Law of Maldistribution

A technique for developing the worth of functions developed in the early days of value analysis and still effective today is comparing the selected function to the simplest method or product that can be imagined. A technique to assign worth of functions that has become increasingly popular is to ascertain the primary material cost associated with the function.[32]

The value calculation can be done in many ways. For example, some workshop facilitators use a ratio of "percent relative importance" to "percent of cost." In this approach, all functions are evaluated pairwise, with different numbers assigned to reflect the relative importance of the two functions being compared (e.g., 3 may mean a large difference in importance, 1 may mean a small difference in importance). A relative importance is calculated for each function individually as the sum of the relative importance scores that function received when it was ranked higher than another function in the pairwise comparisons. The "percent relative importance" is calculated by converting the individual function relative importance scores to a percentage of the total. The "percent of cost" is the cost of a function relative to the total cost of all functions.[33]

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32 SAVE International, "Function: Definition and Analysis," October 1998.

33 A more complete description can be found in Arthur E. Mudge, "Value Engineering—A Systematic Approach," J. Pohl Associates, 1989, pp. 68–74.

Snodgrass[34] suggests another approach based on high, medium, and low scores for function acceptance, function cost, and function importance.

Whatever approach is used, the best opportunities for improvement are determined by improving functions having excessively low ratios of worth to cost. This ratio is referred to as the value index.

6. Refine Study Scope

As a final activity in the Function Analysis Phase, the study scope is refined to reflect the changes that have taken place.

D. CREATIVE PHASE

The purpose of the Creative Phase is to develop a large number of ideas for alternative ways to perform each function selected for further study. The two approaches to solving a problem are analytical and creative. In the analytical approach, the problem is stated exactly and a direct, step-by-step approach to the solution is taken. An analytical problem is one that frequently has only one solution that will work. The creative approach is an idea-producing process specifically intended to generate a number of solutions, each of which solves the problem at hand. All solutions could work, but one is better than the others; it is the optimum solution among those available. Once a list of potential solutions is generated, determining the best value solution is an analytical process (as discussed in the latter phases of the job plan).

Creative problem-solving techniques are an indispensable ingredient of effective VE. By using the expertise and experience of the study team members, some new ideas will be developed. The synergistic effect of combining the expertise and experience of all team members will lead to a far greater number of possibilities. The subsections that follow describe the activities in the Creative Phase (also called the Speculation Phase).

1. Discourage Creativity Inhibitors

For these processes to work well, mental attitudes that retard creativity must be overcome. The facilitator should point out creativity inhibitors to the study team.

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[34] Thomas J. Snodgrass, "Function Analysis and Quality Management," *SAVE International Annual Conference Proceedings*, 1993.

Awareness of these inhibitors encourages people to overcome them. Parker identifies the following as common habitual, perceptual, cultural, and emotional blocks to creativity:[35]

- Habitual Blocks:
  - Continuing to use "tried and true" procedures even though new and better ones are available.
  - Rejection of alternative solutions that are incompatible with habitual solutions.
  - Lack of positive outlook, lack of effort, conformity to custom, and reliance on authority.
- Perceptual Blocks*:*
  - Failure to use all the senses for observation.
  - Failure to investigate the obvious.
  - Inability to define terms.
  - Difficulty in visualizing remote relationships.
  - Failure to distinguish between cause and effect.
  - Inability to define the problem clearly in terms that will lead to the solution of the real problem.
- Cultural Blocks*:*
  - Desire to conform to proper patterns, customs, or methods.
  - Overemphasis on competition or cooperation.
  - The drive to be practical above all else, thus making decisions too quickly.
  - Belief that all indulgence in fantasy is a waste of time.
  - Faith only in reason and logic.
- Emotional Blocks*:*
  - Fear of making a mistake or of appearing foolish.
  - Fear of supervisors and distrust of colleagues.
  - Too much emphasis on succeeding quickly.
  - Difficulty in rejecting a workable solution and searching for a better one.
  - Difficulty in changing set ideas (no flexibility) depending entirely upon judicial (biased) opinion.
  - Inability to relax and let incubation take place.

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35 Donald E. Parker, *Value Engineering Theory*, The Lawrence D. Miles Value Foundation, Washington D.C., 1998, revised edition, p. 93.

The following list adapted from Thiry's "good idea killers" could also be pointed out to the team as attitudes to avoid:[36]

- It is not realistic.
- It is technically impossible.
- It does not apply.
- It will never work.
- It does not correspond to standards.
- It is not part of our mandate.
- It would be too difficult to manage.
- It would change things too much.
- It will cost too much.
- Management will never agree.
- We do not have time.
- We have always done it that way.
- We already tried it.
- We never thought of it that way.
- We are already too far.

It should be emphasized that the Creative Phase does not necessarily identify final solutions or ideas ready for immediate implementation. It often provides leads that point to final solutions.

Beginning the Creative Phase with a creativity-stimulating exercise can also be useful. Kaufman and McCuish[37] report a threefold increase in ideas with the use of such a stimulus.

2. Establish Ground Rules

The ground rules for creative idea generation, as adapted from Parker,[38] are summarized as follows:

- Do not attempt to generate new ideas and judge them at the same time. Reserve all judgment and evaluation until the Evaluation Phase.

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36 Michel Thiry, "*Value Management Practice*," Project Management Institute, 1997, p. 57.

37 J. Jerry Kaufman and James D. McCuish, "Getting Better Solutions with Brainstorming," *SAVE International Annual Conference Proceedings*, Volume XXXVII, Denver, Colorado, 5–8 May 2002.

38 Donald E. Parker, *Value Engineering Theory*, The Lawrence D. Miles Value Foundation, Washington D.C., 1998 revised edition, p. 96.

- Focus on quantity, not quality. Generate a large quantity of possible solutions. As a goal, multiply the number of ideas produced in the first rush of thinking by 5 or even 10.
- Seek a wide variety of solutions that represent a broad spectrum of attacks upon the problem; the greater number of ideas conceived, the more likely there will be an alternative that leads to better value.
- Freewheeling is welcome. Deliberately seek unusual ideas.
- Watch for opportunities to combine or expand ideas as they are generated. Include them as new ideas; do not replace anything.
- Do not discard any ideas, even if they appear to be impractical.
- Do not criticize or ridicule any ideas. (It may be useful to turn the tables on criticism by, for example, maintaining a criticizer list or imposing a mock penalty on criticizers.)

3. Generate Alternative Ideas

In this phase of the study, it is important to generate a free flow of thoughts and ideas for alternative ways to perform the functions selected for study, not how to design a product or service. While creativity tools are available for problem-solving situations, no specific combination of techniques is prescribed for all VE efforts, nor is the degree to which they should be used predetermined. The selection of specific techniques and the depth to which they are used is primarily a matter of judgment and varies according to the complexity of the subject under study.

The following describes some idea-generation techniques commonly used in the VE context:[39]

- *Brainstorming.* Brainstorming is a free-association technique groups use to solve specific problems by recording ideas individuals in the group spontaneously contribute. Brainstorming is primarily based on the premise that one idea suggests others, and these suggest others, and so on. Brainstorming could be done by an individual, but experience has shown that a group can generate more ideas collectively than the same number of persons thinking individually. Sperling[40] has suggested combining group and individual brainstorming. He found that after the group brainstorming process was

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39 Some of the following material was adapted from information in Army Pamphlet 11-3, "Value Engineering" (undated), and DoD Handbook 4245.8-H, "Value Engineering," March 1986.

40 Roger B. Sperling, "Enhancing Creativity with Pencil and Paper," *SAVE International Annual Conference Proceedings*, Volume XXXIV, San Antonio, Texas, 27–30 June 1999, pp. 284–289.

complete, individual brainstorming can generate additional ideas of comparable quality.

- *Gordon Technique.* The Gordon technique is closely related to brainstorming. The principal difference is that no one except the group leader knows the exact nature of the problem under consideration. This difference helps avoid premature ending of the session or egocentric involvement. A participant may cease to produce additional ideas or devote energy only to defending an idea if convinced that one of the already proposed ideas is the best solution to the problem. It is more difficult to select a topic for such a session than for a brainstorming session. The subject must be closely related to the problem at hand, but its exact nature must not be revealed until the discussion is concluded.
- *Checklist.* This technique generates ideas by comparing a logical list of categories with the problem or subject under consideration. Checklists range in type from the specialized to the extremely generalized.
- *Morphological Analysis.* Morphological analysis is a structured, comprehensive system for methodically relating problem elements to develop new solutions. In this approach, the problem is defined in terms of its dimensions or parameters, and a model is developed to visualize every possible solution. Problems with too many parameters rapidly become intractable.
- *Attribute Listing.* This approach lists all the various characteristics of a subject first and then measures the impact of changes. By so doing, new combinations of characteristics (attributes) that will better fulfill some existing need may be determined.
- *Input-Output Technique.* The input-output technique (1) establishes output, (2) establishes input as the starting point, and (3) varies combinations of input/output until an optimum mix is achieved.
- *Theory of Inventive Problem Solving (TRIZ).* TRIZ is a proven management tool whose use will increase with greater awareness of its capabilities. The methods and tools are embodied in a five-step process: problem documentation and preliminary analysis; problem formulation; prioritization of directions for innovation; development of concepts; and evaluation of results. Dull points out that VE and TRIZ have strengths and weaknesses.[41] Combining these two problem-solving methodologies can create synergies that lead to more robust and comprehensive results, especially for more technically complex projects where the added benefit is worth the effort. He suggests it is easier to integrate TRIZ into the VE job plan than vice-versa and provides an example of a way to do so. Clarke goes into greater detail in the Creative Phase by suggesting how

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41 C. Bernard Dull, "Comparing and Combining Value Engineering and TRIZ Techniques," *SAVE International Annual Conference Proceedings,* Volume XXXIV, San Antonio, Texas, 27–30 June 1999, pp. 71–76.

TRIZ can be used to augment traditional brainstorming.[42] Ball supports Clarke's conclusion: "This is a much more intensive method of identifying potential solutions than generally used in a VM study."[43]

When using any one of these techniques, review (and rearrange) the elements of the problem several times. If possible, discuss the problem with others to get a new viewpoint. Try different approaches if one technique is not effective.[44] Before closing the book on possible solutions, take a break to allow time for subconscious thought on the problem while consciously performing other tasks.

E. EVALUATION PHASE

The purpose of the Evaluation Phase is to refine and select the best ideas for development into specific value improvement recommendations. Ultimately, the decision-maker should be presented with a small number of choices. In the Creative Phase, there was a conscious effort to prohibit judgmental thinking because it inhibits the creative process. The Evaluation Phase must critically assess all the alternatives to identify the best opportunities for value improvement. This phase is not the last chance to defer ideas; detailed cost-benefit analyses conducted in the Development Phase lead to the final set of choices presented to the decision-maker. The following subsections describe the activities in the Evaluation Phase.

1. Eliminate Low Potential Ideas

Eliminate ideas that are not feasible, not promising, or do not perform the basic function. A useful approach to this activity is to classify the ideas into three categories:

- *Yes:* These ideas appear to be feasible and have a relatively high probability of success.
- *Maybe:* These ideas have potential but appear to need additional refinement or work before they can become proposals.

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42 Dana W. Clarke, Sr., "Integrating TRIZ with Value Engineering: Discovering Alternative to Traditional Brainstorming and the Selection and Use of Ideas," *SAVE International Annual Conference Proceedings*, Volume XXXIV, San Antonio, Texas, 27–30 June 1999, pp. 42–51.

43 Henry A Ball, "Value Methodology—The Link for Modern Management Improvement Tools," *SAVE International Annual Conference Proceedings*, Volume XXXVIII, Scottsdale, Arizona, 8–11 June 2003.

44 Some work has been done on a systematic approach for moving between creative methodologies. See Donald Hannan, "A Hybrid Approach to Creativity," *SAVE International Annual Conference Proceedings* Volume XXXVI, Fort Lauderdale, Florida, 6–9 May 2001.

- *Not Now:* These ideas have little or no potential at this time.

At this point, eliminate only the "not now" ideas.

2. Group Similar Ideas

Group the remaining ideas into several (three or more) subject-related categories. Examine the ideas to determine if they should be modified or combined with others. Sometimes the strong parts of two different ideas can be developed into a winning idea. In other cases, several ideas may be so similar that they can be combined into a single all-encompassing idea. Some workshops employ a "forced relationships" technique that deliberately attempts to combine ideas from the different subject-related categories in order to discover new, innovative alternatives.

3. Establish Idea Champions

The remaining activities in this phase are designed to prioritize the ideas for further development. An idea champion is a study team member who will serve as a proponent throughout the prioritization process. If an idea has no champion, it should be eliminated at this point.

4. List the Advantages and Disadvantages of Each Idea

Identify advantages and disadvantages of each idea. At a minimum include relative ease of change, cost, savings potential, time to implement, degree to which all requirements are met, and likelihood of success. Try to anticipate all of the effects, repercussions, and consequences that might occur in trying to accomplish a solution.

It is also useful to suggest how to overcome the disadvantages. No matter how many advantages an idea has, disadvantages that cannot be overcome may lead to its rejection.

5. Rank the Ideas

Develop a set of evaluation criteria to judge the ideas using the factors considered when listing advantages and disadvantages (e.g., cost, technical feasibility, likelihood of approval, time to implement, and potential benefit). Rank the ideas according to the criteria developed. No idea should be discarded; all should be evaluated as objectively as possible. Ratings and their weights are based on the judgment of the people performing the evaluation. Techniques such as evaluation by comparison, numerical evaluation, or

team consensus may be used. Chang and Liou suggest using a simplified risk identification and analysis process to evaluate the performance of alternatives and combine these results with criteria weights to determine the best alternatives for further development.[45]

This initial analysis will produce a shorter list of alternatives, each of which has met the evaluation standards set by the team. At this point in the Evaluation Phase, it may be useful to adapt an idea suggested by Pucetas for the Creative Phase. Pucetas recommends using Force Field Analysis to "measure the sensitivity of the VE team regarding controversial project issues."[46] For the higher ranked ideas, the VE team should suggest ways to improve upon the disadvantages and enhance the advantages. This exercise can lead to the following potential benefits:

- Ideas may be revised to improve their potential for success.
- Insight into implementation issues may be obtained from the suggested ways to improve the disadvantages.
- Insight into the acceptability of the idea and the likelihood of management approval may be derived from suggested ways to enhance the advantages.

This approach can therefore serve as a basis for distinguishing among the higher ranked ideas (i.e., re-ranking them) and consequently simplifying and strengthening the process of selecting ideas for further development.

6. Select Ideas for Further Development

Typically, a cutoff point is established for identifying ideas for further development. If there is a natural break in quantitative evaluation scores, a cutoff point may be obvious. If only qualitative evaluation scores are used, or quantitative scores are very close, a more refined ranking scheme may be needed to make the selection. However, if several alternatives are not decisively different at this point, they should all be developed further.

Alternatives with the greatest value potential will normally be among those selected. If that is not the case, reexamine those ideas to determine whether they should

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45 Yuh-Huei Chang and Ching-Song Liou, "Implementing the Risk Analysis in Evaluation Phase to Increase the Project Value," *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005.

46 John D. Pucetas, "Keys to Successful VE Implementation," *SAVE International Annual Conference Proceedings*, Volume XXXIII, Washington, D.C., 14–17 June 1998, p. 340.

also be developed further. It is also useful to retain at least one idea from each of the subject-related categories used to group ideas at the beginning of the Evaluation Phase.

F. DEVELOPMENT PHASE

The purpose of the Development Phase is to determine the "best" alternative(s) for presentation to the decision-maker. In the Development Phase, detailed technical analyses are made for the remaining alternatives. These analyses form the basis for eliminating weaker alternatives. The activities in this phase are described in the following subsections.

1. Conduct a Life-Cycle Cost Analysis

Life-cycle cost is the economic measure of value. A life-cycle cost analysis must rank all remaining alternatives according to an estimate of their life-cycle cost-reduction potential relative to the present method. Cost estimates must be as complete, accurate, and consistent as possible to minimize the possibility of error in assessing the relative economic potential of the alternatives. Specifically, the method used to cost the original or present method should also be used to cost the alternatives.

Be thorough in identifying all costs. For the originating organization, costs may include:

- New tools or fixtures;
- Additional materials;
- New assembly instructions;
- Changes to plant layout and assembly methods;
- Revisions to test and/or inspection procedures;
- Retraining assembly, test, or inspection personnel;
- Reworking parts or assemblies to make them compatible with the new design; or
- Tests for feasibility.

Other costs not normally incurred by the originating activity but that should be considered include:

- Technical and economic evaluation of proposals by cognizant personnel;
- Prototypes;
- Testing the proposed change, including laboratory, firing range, and missile-range charges;

- Additional Government-furnished equipment that must be provided;
- If applicable, retrofit kits (used to change design of equipment already in field use);
- Installation and testing of retrofit kits;
- Changes to engineering drawings and manuals;
- Training Government personnel to operate and maintain the new item;
- Obtaining new and deleting obsolete Federal stock numbers;
- "Paperwork" associated with adding or subtracting items from the Government supply system;
- Maintaining new parts inventory in the supply system (warehousing);
- Purging the supply system of parts made obsolete by the change; and
- Changing the contract work statements and specifications to permit implementation of the proposal.

It is not always possible to determine the precise cost of certain elements of a change. For example, it is difficult to obtain the actual cost of revising, printing, and issuing a page of a maintenance manual. Nevertheless, this is a recognized item of cost, because the manual must be changed if the configuration of the item is changed. It is common practice to use a schedule of surcharges to cover areas of cost that defy precise determination. Such a schedule is usually based on the average of data obtained from various sources.

It is easier to compare alternatives using a "constant dollar" analysis in lieu of a "current dollar" approach. This permits labor and material cost estimates to be based on current operational and maintenance data and eliminates the need to figure out how they would inflate in some future year. Therefore, the net present worth of each of the alternatives should be calculated, but only after there is management agreement on the following two factors:

- The discount rate to be used. This is the difference between the inflation rate assumed and the time value of money (interest rate).
- The length of the life cycle. This is the number of years of intended use or operation of the object being studied.

The Office of Management and Budget Circular A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," provides annual guidance on appropriate discount rates to use. Normally, the Defense Department allows a period of 15–20 years as a reasonable life cycle. However, program or command may have guidance for a particular situation.

2. Determine the Most Beneficial Alternatives

Certain key questions should be answered as part of this effort:

- What are the life-cycle savings?
- Do the benefits outweigh the costs?
- What are the major risks?
- How can the risks be mitigated?
- Are there any outstanding technical issues?

If more than one alternative offers a significant savings potential, it is common to recommend all of them. One becomes the primary recommendation and the others are alternative recommendations, usually presented in decreasing order of saving potential. Take other non-quantified benefits into account.

The VE team should consult with personnel knowledgeable about what the item must do, the operational constraints it faces, how dependable the item must be, and what environmental conditions it must operate under. Technical problems related to design, implementation, procurement, or operation must be determined and resolved.

3. Develop Implementation (Action) Plans

The implementation plan for each alternative should include a schedule of the steps required to implement the idea, who is to do it, the resources required, the approval process, the documents needed, the timing requirements, coordination required, and so on. Anticipate problems relating to implementation and propose specific solutions to each. Particularly helpful in solving such problems are conferences with specialists in relevant areas.

When needed, testing and evaluation should be planned for and scheduled in the recommended implementation process. Occasionally, a significant reduction in implementation investment is made possible by concurrent testing of two or more proposals. Also, significant reductions in test cost can often be achieved by scheduling tests into other test programs scheduled within the desirable time frame. This is particularly true when items to be tested are a part of a larger system also being tested. However, care must be exercised in instances of combined testing to prevent masking the feasibility of one concept by the failure of another.

G. PRESENTATION PHASE

The purpose of the Presentation Phase is to obtain a commitment to follow a course of action for initiating an alternative. A presentation to the decision-maker (or study sponsor) is made at the conclusion of the workshop. This presentation is normally the first step (not the last step) in the approval process. Typically, a decision to implement is not made at the time of the briefing. Additional steps include:

- Answering additional questions,
- Collection of additional data,
- Review of supporting documentation, and
- Involvement of other decisions-makers.

The sole activity in this phase is preparation of a presentation to encourage commitment. An oral presentation can be the keystone to selling a proposal. It should make an impact and start the process of winning management and other stakeholder support. The presentation gives the VE team a chance to ensure that the written proposal is correctly understood and that proper communication exists between the parties concerned. The presentation's effectiveness will be enhanced if:

- The entire team is present and is introduced;
- The presentation lasts no longer than 20 minutes with time for questions at the end;
- The presentation is illustrated using mockups, models, slides, vu-graphs, or flip charts; and
- The team is prepared with sufficient backup material to answer all questions during the presentation.

The presentation should:

- Describe the workshop objectives and scope,
- Identify the team members and recognize their contributions,
- Describe the "before" and "after" conditions for each alternative,
- Present the costs and benefits/advantages and disadvantages/impact of each alternative,
- Identify how to overcome roadblocks,
- Demonstrate the validity of the data sources, and
- Suggest an action plan and implementation schedule.

Many suggestions may be offered to improve the probability of success and reduce the time required for acceptance and implementation of proposals. Those that appear to be most successful are as follows:

- *Consider the reviewer's needs.* Use terminology appropriate to the training and experience of the reviewer. Each proposal is usually directed toward two audiences. First is the technical authority that requires sufficient technical detail to demonstrate the engineering feasibility of the proposed change. Second are the administrative reviewers for whom the technical details can be summarized while the financial implications (implementation's cost and likely benefits) are emphasized. Long-range effects on policies, procurement, and applications are usually more significant to the administrator than to the technical reviewer.
- *Address risk.* Decision-makers are often more interested in the risk involved in making a decision than the benefits or value that might be achieved. Do not confuse decision-making risk with technical risk. Decision-making risk encompasses the uncertainty and complexity generated from making change. Therefore, consider the organizational culture and behavior when characterizing the recommendation.
- *Relate benefits to organizational objectives.* If the proposal represents advancement toward some approved objective, it is most likely to receive favorable consideration from management. Therefore, the presentation should exploit all the advantages a proposal may offer toward fulfilling organizational objectives and goals. When reviewing a proposal, the manager normally seeks either lower total cost of ownership or increased capability at the same or lower cost. The objective may be not only savings but also the attainment of some other mission-related goal of the manager.
- *Show collateral benefits of the investment.* Often, VE proposals offer greater benefits than the cost improvement specifically identified. Some of the benefits are collateral in nature and may be difficult to quantify. Nevertheless, collateral benefits should be included in the proposal. The likelihood of acceptance of the proposal is improved when all its collateral benefits are clearly identified and completely described.

The Presentation Phase should end with a list of actions leading to approval:

- Preparation and submission of a final workshop report with all the necessary supporting documentation,
- Briefings to other key stakeholders, and
- A schedule for a follow-up meeting to approve the proposal.

H. IMPLEMENTATION PHASE

The purpose of the Implementation Phase is to obtain final approval of the proposal and facilitate its implementation. Throughout this phase, it is useful to keep in mind factors that contribute to successful change:

> The VE/VA techniques provide an excellent method for planned and managed change. However, even when the job plan is applied well, challenges to the change process occur due to individual differences and human interpretation. At each stage of the change process, a number of varying responses may be expected from individuals involved throughout the organization. These responses range from active support to resistance. One of the approaches that has demonstrably improved the chances for success of the planned change and reduced reactive resistance is to let people in on the action—to participate in the decision-making process.[47]

Fraser goes on to note the five factors Kolb and Boyatzis have identified as most highly related to goal achievement: awareness, expectation of success, psychological safety, measurability of the change goal, and self-controlled evaluation.[48]

VE is ideally suited to meeting these challenges. The following subsections depict a typical sequence of events.

1. Prepare a Written Report

It is unusual to base a decision only on the basis of an oral presentation; supporting documentation is normally required. Therefore, the results of the study should also be documented in written form. Failure to provide adequate documentation is a prime factor in proposal rejection.

Oral presentation of study results is most helpful to the person who is responsible for making the decision; however, it should never replace the written report. A written report normally demands and receives a written reply; whereas oral reports can be forgotten and overlooked after they are presented. In the rush to wrap up a project, promote a great idea, or save the laborious effort of writing a report, many proposals have fallen by the wayside because the oral presentation came first and was inadequate. The

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47 R. A. Fraser, "The Value Manager as Change Agent: or 'How to be a Good D*eviant,'" SAVE International Annual Conference Proceedings*, Volume XIX, Sacramento, California, 6–9 May 1984, pp. 199–203.

48 David A. Kolb and Richard E. Boyatzis, "Goal Setting and Self-Directed Behavior Change," in David A. Kolb, Irwin M. Rubin, James M. McIntyre, *Organizational Psychology: A Book of Readings*, Prentice-Hall, 1979.

systematic approach of the VE job plan must be followed all the way through to include the meticulous and careful preparation of a written report. Like any other well-prepared staff report, this final report should:

- Satisfy questions the decision-maker is likely to ask,
- Provide assurance that approval would benefit the organization,
- Include sufficient documentation to warrant a favorable decision with reasonable risk factors (both technical and economic), and
- Show how performance is not adversely affected.

The report should be accompanied by a team letter that summarizes the recommendation and action plan. This letter should also request action from the sponsor. Send the letter and the report to all stakeholders.

2. Enhance the Probability of Approval

Approval of a proposal involves change to the status quo. Because of this, or other pressing priorities, a manager may be slow in making a decision. The manager who makes an investment in a VE study expects to receive periodic progress reports before a final decision is made. Regular reporting helps ensure top management awareness, support, and participation in any improvement program. Therefore, it is advisable to discuss the change with the decision-makers or their advisors both before and after submitting the final report. This practice familiarizes key personnel with impending proposals and enables a more rapid evaluation. Early disclosure may also serve to warn the originators of any objections to the proposal. This “early warning” will give the originators opportunity to incorporate explanations and details into the final report to overcome the objections. These preliminary discussions often produce additional suggestions that improve the proposal and enable the decision-maker to contribute directly.

Implementation depends on the expeditious approval by the decision-makers in each organizational component affected by the proposal. The VE team should become liaisons between decision-makers and stakeholders by preparing information that weighs the risk against the potential reward and thinking about potential roadblocks to determine, in advance, how they should be overcome.

Some organizations have found it helpful to convene an implementation meeting with all stakeholders.[49] Once tentative decisions have been made, this meeting is used to help everyone understand which proposals or modified proposals have been accepted, rejected, or will be studied further. In some cases, the tentative decisions are changed based on a clarification of a misunderstood assumption.

3. Monitor Progress

Implementation progress must be monitored just as systematically as the VE study. It is the responsibility of the VE study team to ensure that implementation is actually achieved. A person could be given the responsibility of monitoring deadline dates in the implementation plan and the process for obtaining any implementation funding.

4. Expedite Implementation

To minimize delays in the implementation process, use the knowledge gained by those who originated it. The VE team should be called on to provide assistance, clear up misconceptions, and resolve problems that may develop. In addition, where possible, the VE team should prepare first drafts of documents necessary to revise handbooks, specifications, change orders, drawings, and contract requirements. Such drafts will help to ensure proper translation of the idea into action and will serve as a baseline from which to monitor progress of final implementation. The VE team should review all implementation actions to ensure communication channels are open and that approved ideas are not compromised by losing their cost effectiveness or basis for original selection.

5. Follow-up

The final activity of the Implementation Phase includes several diverse tasks that foster and promote the success of subsequent VE efforts:

- Obtain copies of all complete implementation actions,
- Compare actual results with original expectations,
- Submit cost savings or other benefit reports to management,
- Submit technical cross-feed reports to management,

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[49] Jill Ann Woller, "Value Analysis: An Effective Tool for Organizational Change," *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005.

- Conduct a “lessons-learned” analysis of the project to identify problems encountered and recommend corrective action for the next project,
- Publicize accomplishments,
- Initiate recommendations for potential VE study on ideas evolving from the study just completed, and
- Screen all contributors to the effort for possible receipt of an award and initiate recommendation for appropriate recognition.

I. CONCLUDING COMMENTS

Although the job plan process may seem intimidating, it is a proven tool for successfully using VE to address any problem. It usually involves a trained facilitator and can be tailored to the individual circumstances. As with almost any decision-making endeavor, the first and last phases are the most important. There are countless variations on how to conduct the analyses. In the first phase, determining the right problem and putting together the facts and the team to deal with them are critical. In the last phase, after a decision is made, follow-through of its implementation is essential. If the implementation is not successful, no savings will be realized.

VI. ESTABLISHING A VE PROGRAM

A VE program cannot be established in a vacuum. It must be fully integrated with other organizational activities. Value engineering can be thought of as an enterprise change initiative. As early as 1984, Fraser[50] wrote:

> The role of the value engineer/analyst involves managing change—from developing problem-solving skills of team members to increasing the acceptance of change proposals throughout the organization.

Rains[51] built on Fraser's theme. In the process of developing a FAST diagram for the value practitioner, he chose "encourage change" as the primary basic function and discussed how he perceived creativity to be a catalyst for change. The lower level basic functions were as follows:

cause interaction → promote teamwork → form teams → develop topics/projects

As discussed in Chapter V, moving left to right across the basic functions keeps answering the question, "How?" Change is encouraged by causing interaction. This interaction is accomplished by promoting teamwork as a result of forming teams. Finally, since teams are formed by people with the expertise required to work on a specific project, developing topics or projects is how to form teams. Moving from right to left along the same path explains why. Projects are developed in order to form teams to solve them. The teams are formed to promote teamwork needed to cause the interactions necessary to encourage change.

To avoid conflict and competition with other enterprise-wide initiatives, Section A compares, and discusses the relationships between, VE and a subset of enterprise change models or methodologies used in the Defense Department. Beyond these four methodological, tool-based approaches to change, the Defense Department is also attempting to change its paradigm for affordability by encouraging systems to focus on

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50 R. A. Fraser, "The Value Manager as Change Agent: or 'How to be a Good Deviant,'" *SAVE International Annual Conference Proceedings,* Volume XIX, Sacramento, California, 6–9 May 1984, pp. 199–203.

51 James A. Rains, Jr., "What is the Function of a Value Practitioner?—'Encourage Change'!" *SAVE International 45th Annual Conference Proceedings,* San Diego, California, 26–29 June 2005.

life-cycle value across the enterprise. Section B describes the linkage between VE and the Department's umbrella weapon-system-related cost-reduction initiative, Reduction of Total Ownership Costs (R-TOC).

Section C concludes with a brief overview of some best practices for establishing a VE capability in an organization.

A. INTEGRATING VE WITH ENTERPRISE CHANGE MODEL INITIATIVES

Four enterprise change models will be discussed in Subsection 1. Subsection 2 describes how VE interacts with them.

1. Enterprise Change Model Overviews

The following provides a short overview of the following four enterprise change models:

- Lean Thinking,
- Six Sigma,
- Theory of Constraints, and
- Business Process Reengineering.

To learn more about these models, a bibliography of sources of further information is also provided.

a. Lean Thinking

Lean thinking is the dynamic, knowledge-driven, and customer-focused process through which all people in a defined enterprise continuously eliminate waste with the goal of creating value. It uses a continuous-improvement process whose steps are as follows:

- *Visualize:* Visualize the desired future state and establish goals.
- *Commit:* Commit to change.
- *Prioritize:* Determine improvement priorities.
- *Characterize:* Define existing process/leverage points.
- *Improve:* Design and implement improvements.
- *Achieve:* Hold the gains and plan for future improvements.

See the following references for further information:

- Earll Murman, Thomas Allen, Kirkor Bozdogan, Joel Cutcher-Gershenfeld, Hugh McManus, et al., *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative*, Houndmills, Basingstoke, Hampshire RG21 6XS, Great Britain: Palgrave, 2002.
- James P. Womack, and Daniel T. Jones, "From Lean Production to the Lean Enterprise," *Harvard Business Review* (March-April 1994), pp. 93–103.
- James P. Womack, and Daniel T. Jones, *Lean Thinking: Banish Waste and Create Wealth in your Corporation*, New York: Simon & Schuster, 1996.
- James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine that Changed the World*, New York: Rawson Associates, 1990.

b. Six Sigma

Six Sigma can be characterized as a data-driven approach to continuous process improvement. It seeks to eliminate all sources of variation across the enterprise. The basic steps of a Six Sigma improvement process may be characterized as follows:

- *Define:* Define customer requirements and develop a map of the process to be improved.
- *Measure:* Identify key measures of effectiveness and efficiency and translate them into the concept of sigma.
- *Analyze:* Analyze the causes of the problem requiring improvement.
- *Improve:* Generate, select, and implement solutions.
- *Control:* Ensure that improvement is sustained over time.

See the following references for further information:

- *Design for Six Sigma: The Revolutionary Strategy for Achieving Extraordinary Profits*, Dearborn Trade, A Kaplan Professional Company, 2002.
- Forrest W. Breyfogle III, James M. Cupello, and Becki Meadows, *Managing Six Sigma: A Practical Guide to Understanding, Assessing and Implementing the Strategy that Yields Bottom-Line Success*, New York: John Wiley & Sons, Inc., a Wiley-Interscience Publication, 2001.
- George Eckes, *The Six Sigma Revolution: How General Electric and Others Turned Process into Profits*, New York: John Wiley & Sons, Inc., 2001.
- George Eckes, *Making Six Sigma Last* New York: John Wiley & Sons, Inc., 2001.

c. Theory of Constraints

The theory of constraints seeks to maximize throughput (the rate that the system generates money) by understanding and eliminating bottlenecks. Its overarching implementation framework may be characterized as follows:

- Establish the goal of the system, the units of measurement, and the operating measurements;
- Understand the system;
- Stabilize the system;
- Identify the constraint and carry out five focusing steps to decide how to overcome it;
- Implement buffer management;
- Reduce the variability of the constraint and the main processes;
- Create a suitable management structure;
- Eliminating the external constraint, selling excess capacity; and
- Establish a continuous-learning program.

See the following references for further information:

- Eliyahu M. Goldratt, *Theory of Constraints*, Croton-on-Hudson, New York: North River Press, Inc., 1990.
- Eliyahu M. Goldratt, *The Haystack Syndrome*, Croton-on-Hudson, New York: North River Press, Inc., 1990.
- Eliyahu M. Goldratt, *What Is This Thing Called Theory of Constraints and How Should It Be Implemented?* North River Press, December 1999.
- Eliyahu M. Goldratt with Eli Schragenheim and Carol A. Ptak, *Necessary but Not Sufficient*, Great Barrington, Mass.: The North River Press, 2000.
- Domenico Lepore and Oded Cohen, *Deming and Goldratt: The Theory of Constraints and the System of Profound Knowledge*, Great Barrington, Mass.: The North River Press, 1999.

d. Business Process Reengineering

Business process reengineering is the rethinking and redesign of business processes to achieve dramatic improvements in performance. One characterization of steps in the process is as follows:

- Determine the business vision and process objectives,
- Identify the processes to be redesigned,
- Understand and measure the existing processes,

- Develop alternatives for the process elements under consideration,
- Design and build a prototype of the new process,
- Evaluate the effects of the change, and
- Transform the business process across the enterprise.

See the following references for further information:

- Michael Hammer, "Reengineering Work: Don't Automate, Obliterate," *Harvard Business Review*, July-August 1990, pp. 104–112.
- Michael Hammer, *Beyond Reengineering*, New York: Harper Business, a division of HarperCollins, 1996.
- Michael Hammer and James Champy, *Reengineering the Corporation: A Manifesto for Business Revolution*, New York: Harper Business, a Division of HarperCollins Publishers, 1993.
- T. H. Davenport and J. E. Short, "The New Industrial Engineering: Information Technology and Business Process Redesign," *Sloan Management Review*, Summer 1990, pp. 11–27.

2. Relationships of Enterprise Change Models to VE

Several papers authored in the VE community have discussed one or more aspects of the relationship between VE and these enterprise change models. For example:

- Cell and Arratia discuss opportunities for using VE tools and techniques in the lean process. They argue that noteworthy benefits may be achieved by augmenting the VE job plan to specifically find and eliminate the seven wastes identified in lean thinking. Thorsen shows parallels between the VE job plan and value stream mapping as used in lean thinking. Parker describes another approach for integrating lean with VE. The concept of lean has been extended to the construction industry. Lehman and Reiser describe the synergies with VE in that context.[52]
- Cook points out that, although there are distinctions between VE and Six Sigma, there are strong synergies as well. He goes on to describe how the value methodology may be used to help Six Sigma practitioners successfully execute

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[52] Charles L. Cell and Boris Arratia, "Lean Thinking and Value Engineering," *SAVE International Annual Conference Proceedings*, Volume XXXVIII, Scottsdale, Arizona, 8–11 June 2003; William C. Thorsen, *Value Stream Mapping & VM*, SAVE International 45th Annual Conference Proceedings, San Diego, California, 26–29 June 2005; Donald E. Parker, "Integrating Lean with Value Engineering," *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005; and Theresa Lehman and Paul Reiser, "Maximizing Value & Minimizing Waste: Value Engineering & Lean Construction," *SAVE International 44th Annual Conference Proceedings*, Montreal, Quebec, 12–15 July 2004.

their projects and suggests that Six Sigma applications should become an area to market VE capabilities. In a subsequent paper, Cook suggests that organizations intentionally (1) adopt and practice both Six Sigma and VE as key strategies and (2) use them in a complementary manner to compound and enhance the advantages of each and thereby significantly enhance the benefits achieved. Cell points out that synergies between lean thinking and six sigma are increasingly being recognized. He goes on to say that when VE is integrated with them, individual strengths are amplified and weaknesses are overcome. He also suggests an integrated process.[53]

- Ball describes how the theory of constraints and VE work well together. He asserts that function analysis helps identify the constraints and the creative, evaluation, and development activities are similar to exploiting and subordinating the constraints.[54]
- Rus has observed similarities between VE and Business Process Reengineering and proposes integrating the two methodologies. She suggests that the analytical elements of VE would be especially beneficial to the Business Process Reengineering process. Ali and Assaf compare VE to Business Process Reengineering and Six Sigma on the basis of level of training, number of people involved, time to implement, and cost to implement.[55]

All these references are somewhat technical in nature. They have compared strengths, weaknesses, and attributes; examined the tools and processes; and developed ways to improve results by integrating with VE techniques. This document takes a broader perspective. Table 2 compares the four enterprise change models according to

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53 Michael J. Cook, "An Untapped Market: Energizing VM Usage Via the Six Sigma Methodology," *SAVE International Annual Conference Proceedings*, Volume XXXV, Reno, Nevada, 25–28 June 2000, pp. 25–31; Michael J. Cook, "How to Get Six Sigma Companies to Use VM and Function Analysis," *SAVE International Annual Conference Proceedings*, Volume XXXVIII, Scottsdale, Arizona, 8–11 June 2003; and Charles L. Cell, "VE, Lean and Six Sigma—Opportunities for Leverage," *SAVE International 44th Annual Conference Proceedings*, Montreal, Quebec, 12–15 July 2004.

54 Henry A Ball, "Value Methodology—The Link for Modern Management Improvement Tools," *SAVE International Annual Conference Proceedings*, Volume XXXVIII, Scottsdale, Arizona, June 8–11, 2003.

55 Mary J. Rus, "The Value Engineering in Business Process Reengineering—A Back to Basics Approach," *SAVE International Annual Conference Proceedings*, Volume XXXII, Seattle, Washington, 4–7 May 1997, pp. 228–231; and Mir Farooq Ali and Saadi Assaf, "A Qualitative Comparison of Innovative Management Techniques in the Construction Industry," *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005.

their goal, focus, scope, change process, and business model. See Bozdogan[56] for a thorough discussion of the elements of this comparison.

Table 2. Comparison of Enterprise Change Models

	Business Process Reengineering	Theory of Constraints	Six Sigma	Lean
Goal	Breakthrough solutions	Eliminate bottlenecks	Reduce variation in enterprise	Eliminate waste
Focus	Business process	Throughput	All sources of product variation	All enterprise processes and people
Scope	Business unit	Enterprise	Enterprise	Enterprise value stream
Change Process	Radical	Continuous	Process specific, continuous	Evolutionary and systematic
Business Model	Increase enterprise performance and customer value	Increase financial performance of core enterprise	Minimize waste and increase customer satisfaction	Deliver value to all stakeholders

Adapted from Lean Aerospace Initiative Lean Now Workshop, January 2003

There are differences among the approaches. Table 2 shows that each has a different goal, focus, and business model. Some of the models have an enterprise-level scope, while others are narrower. All the models lead to incremental or continuous change. Differences beyond those in the table include the following:

- Each approach has its own identifiable evolutionary path,
- Some tools and characteristics are strongly tied to a single approach,
- Terminology is different, and
- Individual circumstances may lend themselves to one approach over another.

Despite the differences, all these models provide a positive impetus for performance improvement and change, thereby enabling organizations to drastically improve their bottom lines.

Value engineering can be included in Table 2 as follows:

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56 Kirk Bozdogan, "A Comparative Review of Lean Thinking, Six Sigma and Related Enterprise Change Models," Massachusetts Institute of Technology Working Paper, 3 December 2003.

- *Goal:* Increase return on investment.
- *Focus:* Function analysis and function worth.
- *Scope:* Business unit.
- *Change Process:* Incremental.
- *Business Model:* Increase value to the customer.

Again, the differences between VE and the other enterprise change models are not important in practice. Each approach uses its own process as shown in subsection A.1. These processes work; the value methodology works. In fact, the boundaries merge in practice. While each approach may have strengths, rarely will a single approach be right for all aspects of a given situation. The complementary nature of the different approaches leads to synergistic benefits. DoD Components are encouraged to integrate VE with other similar programs.[57]

B. VE AND R-TOC

R-TOC is a key component of the Department's efforts to transform the way in which systems are developed, acquired, operated, and supported. It was established in response to long-standing concerns about the adverse impact of defense budgetary and operational trends on force structure and readiness. Declining procurement funds are resulting in a rapidly aging (and potentially inefficient and unsupportable) inventory. Rising O&S costs can consume higher portions of the defense budget and leave even less available for modernization.

The purpose of the R-TOC program is to control the ever-increasing costs of DoD systems while improving readiness. In recent years, world-class suppliers have achieved cost reductions while making major improvements in customer support. In the R-TOC context, some DoD programs have achieved similar successes through replacing high-cost and low-reliability components, enhancing supply-chain efficiency, using smart decision-support tools with cost visibility, establishing performance-based logistics support arrangement, leveraging commercial off-the-shelf components, and initiating public-private partnerships. The current R-TOC vision and goal are as follows:[58]

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57 DoD Inspector General Issue Resolution Agreement, "Defining Value Engineering (VE) for Reporting Purposes," 22 November 2000.

58 Under Secretary of Defense for Acquisition, Technology and Logistics Memorandum, "Transformation Though Reduction of Total Ownership Costs (R-TOC)," 16 December 2003.

- *Vision:* Through R-TOC principles, all defense systems will perform with increasing readiness and capability while avoiding increased O&S resource costs and improving logistics footprint by institutionalizing the continuous implementation of innovative process and hardware improvements.
- *Goal:* Maximize cost avoidance on total defense systems' FY 2010 O&S costs by offsetting 30 percent of the inflation predicted from an FY 2004 baseline.

The principles of value engineering represent an important element of R-TOC. Just as R-TOC seeks to identify opportunities for savings over the life cycle, VE is designed to emphasize long-term gains with improved technical solutions. As long as some sort of function analysis is used, any cost-reduction initiative can be encompassed under the VE umbrella. VE reduces cost, increases quality, and improves mission capabilities across the entire spectrum of DoD systems, processes, and organizations. It employs a simple, flexible, and structured set of tools, techniques, and procedures that challenge the status quo by promoting innovation and creativity. Furthermore, it gives Government participants and their industry counterparts the incentive to increase their joint value proposition in achieving best value solutions as part of a successful business relationship.

From a policy perspective, the Department of Defense's VE program has established three top-level goals in conjunction with R-TOC:

- VE Goal 1 is to *improve the value proposition for defense systems*. This goal encourages programs to take a methodical approach to examining the functions being performed and identify and implement ways to improve them.
- VE Goal 2 is to help *align industry and government value propositions in defense systems*. VE efforts provide value to the government by reducing program costs while increasing capability. VE simultaneously generates value to industry by allowing shared savings to increase profit margins.
- VE Goal 3 is to *increase VE expertise*. Education and training will become elements of an intensive outreach effort to communicate the opportunities VE provides and how to take advantage of those opportunities. Lee and Gunther describe a practical application showing how the value methodology can be applied throughout a system's lifetime.[59]

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[59] Andrew Lee and Steven Gunther, "VE's Application in Reducing Total Ownership Costs within the Army," *SAVE International Annual Conference Proceedings*, Volume XXXV, 25–28 June 2000, pp. 149–155.

C. BEST PRACTICES FOR ESTABLISHING A VE CAPABILITY IN AN ORGANIZATION[60]

P.L. 104-106 requires each executive agency in the Government to establish and maintain cost-effective VE procedures and processes. The most effective way of complying with this law is through top-management support, institutionalized in written policy that is adequately resourced. The discipline and rigor involved in applying the value methodology usually cannot be sustained in a bottom-up approach. Leadership attention will ensure implementation and continuing support from the entire organization. Setting goals and objectives that can be tracked through metrics provides a rationale for change and an impetus to succeed.

A designated VE leader with open communication channels to top management is also important. That person should have established credibility as a problem solver and possess people and management skills. Knowledge of the VE methodology can be developed over time and capable facilitators can be made available. The leader must:

- Understand the viewpoints of potential customers to convince them that VE can help them achieve their goals. Although some problems may be brought to a VE team, in the beginning, the team must be able to market its capabilities to others in the organization. There are advantages to choosing the problem to attack, since problems brought to the team's attention may be difficult to solve.
- Promote the use of VE techniques by Government personnel.
- Develop orientation training that acquaints others with VE policies, procedures, and benefits.
- Choose projects with a high probability of a favorable outcome (as discussed in Section A). Early failures can be extremely detrimental to a VE program; success builds on success.
- Encourage contractors to respond to the VE clauses in DoD contracts and thereby share the resulting cost savings.
- Focus first on achieving measurable results and second on other intangible benefits. Although there usually are intangible benefits to a VE study, quantifying them can be difficult. Typically, such intangibles are conveyed through anecdotes that may not be convincing to decision-makers evaluating the success of a VE program. It is also important not to promise too much. If

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60 The material in this section draws upon James A. Rains, Jr., "Creating and Maintaining an Effective and Successful Value Analysis Program," *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005.

people's expectations are not met, a successful outcome may not be viewed as such.

- Ensure that management is heavily involved in the Orientation and Implementation Phases of the job plan. The Orientation Phase initially sets the scope and objectives for the projects. These must be aligned with management needs. Making a decision to change does not imply that the expected benefits will be realized. Implementation of the decision is often a long, arduous process. Management must be kept informed to help overcome roadblocks and to avoid surprise.
- Ensure adequate preparation for workshops, including use of proper data sources and a complete plan. Skill in applying the VE methodology does not ensure success. Contingencies must be planned for in advance. If, for example, at the last minute, a key person becomes unable to participate, reschedule the workshop to accommodate the conflict.
- Ensure that the VE methodology is applied carefully and thoroughly (as discussed in Chapter V).
- Publicize VE results to the entire organization. As accomplishments become well known, more opportunities will be presented. Recognize successful accomplishments and fully credit the team and people that developed and implemented the change.
- Provide VE practitioners with ample training to continuously improve their skills (as described in Chapter VII).
- Nominate recipients for the DoD VE Achievement Awards.

D. CONCLUDING COMMENTS

As part of the Defense Department's attempts to reduce the total ownership cost of its weapon systems and infrastructure, application of programs such as Lean, Six Sigma, Theory of Constraints, and Business Process Reengineering does not preclude an active, formal VE effort. VE tools have been proven to help implement these other programs. Applying these disciplines synergistically leads to greater savings and efficiencies. Competition between them decreases their effectiveness.

VII. VE EDUCATION AND TRAINING

There are many possible sources of VE education and training. Nearly all colleges and universities teach disciplines related to the practice of VE. Within the Department of Defense, the Defense Acquisition University offers a course on the contractual aspects of VE along with an online continuous-learning VE overview module. Section A of this chapter summarizes Defense Acquisition University's course offerings.

Some colleges and universities teach the methodology in greater detail. One of the missions of the Lawrence D. Miles Value Foundation is to create and promote teaching of value methodology courses at the university level. Currently, the Foundation has established agreements with several universities to offer certain VE courses.[61]

SAVE International is an international society devoted to advancing and promoting the value methodology. SAVE International offers member services such as education and training, publications, tools for promoting the value methodology, certification, networking, and recognition. SAVE also maintains a directory of "value consultants" who can lead studies or train others in VE techniques and who sponsor courses covering the value methodology and related disciplines. Section B describes SAVE International's professional certification program.

Private companies also provide VE training for their own employees and their customers. Section C presents some ideas about continuing VE education and training beyond certification.

A. DEFENSE ACQUISITION UNIVERSITY

The Defense Acquisition University offers a continuous-learning online course on value engineering.[62] This course provides an overview of value engineering for multidisciplinary Government, military, and civilian personnel, including program

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61 See the Lawrence D. Miles Value Foundation Web site at http://www.valuefoundation.org/honor.htm.

62 A course description for the course, CLE001 Value Engineering, is available online at https://learn.dau.mil/html/clc/Clc.jsp?fTopic=All&fKeywords=Value+Engineering&Submit=Search. The course learning objectives are taken from this Web site.

managers, systems engineers, acquisition and logistics personnel, functional leaders, and contractors. It is divided into six chapters with learning objectives as follows:

- Chapter 1: Introduction to Value Engineering
  - Define Value Engineering
  - Understand the benefits of using Value Engineering for the government
  - Understand the benefits of using Value Engineering for the contractor
- Chapter 2: Applications of Value Engineering
  - Understand where and when Value Engineering can be applied
  - Understand VE misconceptions
  - Describe some VE successes in the Department of Defense
- Chapter 3: Implementation through VE Workshops
  - Understand the benefits of conducting VE workshops
  - Describe how to prepare a workshop
  - Understand the outcomes of a VE workshop
- Chapter 4: Understanding the VE Methodology
  - Describe the phases of VE methodology
- Chapter 5: Using Value Engineering Change Proposals
  - Describe the various types of VE contract clauses
  - List the steps for VECP approval by the government
  - Explain the different types of VE settlements and their application
  - Describe some techniques which will increase the contractor's probability of success for government approval of the VECP
- Chapter 6: Summary of Value Engineering

The Defense Acquisition University also offers a 5-day resident course[63] on the Contractual Aspects of Value Engineering.[64] This assignment-specific course is for contracting, program management, and functional personnel who may be involved in VE applications or who support major weapon systems and can be expected to encounter specific VE activity. Although the course is targeted for contracting personnel, individuals not assigned to contracting are encouraged to attend. This course provides an intensive review of the techniques and objectives of the DoD Value Engineering

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63 The course is expected to be online by 2007.

64 The following material was extracted from the 2005 DAU course catalog available online at http://www.dau.mil/catalog/Catalog_2005.asp. (The most recent catalog is available at http://www.dau.mil/catalog.)

program. Students are exposed to basic VE concepts and definitions and the relationship of VE to other incentives contained in contracts and subcontracts. The objectives are as follows:

- Apply the appropriate VE clause by differentiating among the types of VE programs;
- Validate, by assessment, VE Change Proposals;
- Calculate savings resulting from accepted VECPs; and
- Modify the contract after formal processing and acceptance of the VECP.

In addition, the Defense Acquisition University includes value engineering as one of its systems engineering management tools. The Defense Acquisition University's Advanced Science and Technology Management Course (STM 302) briefly covers this material.

B. PROFESSIONAL CERTIFICATION[65]

Individuals may obtain certification in the practice of the Value Methodology through SAVE International. The three levels of certification are available:

- The Associate Value Specialist is at the entry level. Requirements include training in the basics and some limited experience.
- The Value Management Practitioner is at the mid-level. Additional requirements beyond an Associate Value Specialist are experiential. This certification level recognizes those individuals who have acquired the basic skills of value engineering/analysis but their principal career is not value engineering.
- The Certified Value Specialist is the highest level of certification for people whose principle career is value engineering. Advanced training and leadership and managerial experience beyond the Value Management Practitioner are required.

The following are among the certification program's objectives:

- To create and maintain professional standards and improve the practice of the Value Methodology by identifying courses that meet the required education and training criteria.

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65 The material in this section has been extracted from the SAVE International Web site, http://www.value-eng.org/education_certificationprg.php.

- To establish and maintain a professional recognition program encouraging practitioners in the Value Methodology field to improve professional education and training skills and competence in accordance with the standards.
- To clarify methods and procedures in the application of the Value Methodology; to create a better understanding of the value profession; and to develop universal acceptance and increased application of value practices.
- To establish and maintain ethical standards for workshops and seminars.
- To encourage the development and application of the Value Methodology and provide examples of successful application of projects in industry and government.

Topics covered in SAVE International's basic and advanced training courses are as follows:

- Basic Training
  - History, definition, job plan
  - Function, FAST, function-cost
  - Creativity
  - People topics
  - Cost
  - Basis of cost analysis
  - Evaluation and implementation
- Advanced Training:
  - Project and team structure
  - Job plans
  - Function analysis and FAST diagramming
  - Creativity process
  - Financial evaluation
  - Interpersonal skills
  - VM interactions within organizations

SAVE also conducts other training seminars. Topics have included creativity, facilitization skills, FAST, life-cycle costing, and Quality Function Deployment.

Another certification program for VE, the "Value Engineering Leader Certification Program," is registered with the All-Japan Foundation of Management Organizations conducted by the Society of Japanese Value Engineers.

C. CONTINUING EDUCATION

Certification should not be the end of VE training. VE practitioners should continue to build and sharpen their skills. Selecting the most appropriate subjects and the right learning method depends on the organizational and individual preferences. The following provides some especially good ideas along these lines:

- SAVE International's main educational and training opportunity comes at its annual conference. Conference attendees can hone and refine their skills, exchange ideas with peers, listen to presentations illustrating the latest thinking about VE applications, and interact with exhibitors who provide VE products and services.
- Otero, Beadle, and Magaldi[66] describe Pratt & Whitney's internally developed formal training and certification process. This comprehensive program has expanded the use and reputation of the value methodology in the company. The authors list learning objectives for value management practitioner training in the article's appendix.
- Hannan[67] makes the case to expand and enhance VE professional skills using role-specific training programs. He provides several examples (project selection and team building, facilitization tools and techniques, and creative problem-solving strategies) designed to meet the needs of some of his clients. Hannan's concept of role-specific training is not limited to the VE practitioner. He also suggests supporting programs such as value methodology awareness seminars and training for value management team members.
- Fallon[68] describes the body of knowledge underlying the value discipline from a university perspective. He lists the college subjects that provide the basic knowledge behind the VE job plan, as well as useful technical electives at the undergraduate level. Fallon also suggests potential course (and other) requirements for a Master of Science degree in value analysis.

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66 Joseph F. Otero Jr., Timothy T. Beadle, and Christine A. Magaldi, "Accelerating the Development of Value Management Practitioners," *SAVE International Annual Conference Proceedings*, Volume XXXVI, Fort Lauderdale, Florida, 6–9 May 2001.

67 Donald Hannan, "A Re-evaluation of our Profession: Customized Role Specific Training Programs & Client Specific VE Workshops," *SAVE International Annual Conference Proceedings*, Volume XXXVII, Denver, Colorado, 5–8 May 2002.

68 Carlos Fallon, "Body of Knowledge Underlying the Value Disciplines," *SAVE International Annual Conference Proceedings*, Volume XXX, Miami, Florida, 24–26 May, 1971, pp. 19–26. Republished in Value World, Volume 27, Volume 2, Fall 2004, pp. 17–22.

- Cook[69] describes the skills and competencies required to be an outstanding VE consultant. He classifies them in categories of basic traits, supporting skills, interpersonal skills, and technical skills. While explicitly linked to consultants, Cook's work is equally applicable to any VE practitioner. Table 3 lists the subjects that Cook includes under each of the four headings.
- Other VE training programs are available on the Web. See, for example, www.value-engineering.com/training.htm and www.vetoday.com/training.php.

Table 3. Essential VE Consulting Skills

Category	Skill
Baseline	Trustworthiness
	Character
	Authenticity
Supporting	Administrative skills
	Negotiation skills
	Commitment-building skills
	Meeting management
	Expectation management
Technical	Function analysis
	Report-writing and documentation
	FAST diagramming
	Storyboarding
	Analytic skills
	Evaluation techniques
	Problem identification and definition
	Scientific methods
	Decision-making tools
	Scribing techniques
	Creativity techniques
	Financial skills
	Application area knowledge
Interpersonal	Building relationships
	Perception
	Valuing diversity
	Communication skills
	Dealing with resistance
	Resolving Conflict

Source: Michael J. Cook; *Essential VE Consulting Skills*; SAVE International Annual Conference Proceedings; Volume XXXIV; San Antonio, Texas; 27–30 June 1999; pp. 52–60.

69 Michael J. Cook, "Essential VE Consulting Skills," *SAVE International Annual Conference Proceedings*, Volume XXXIV, San Antonio, Texas, 27–30 June 1999, pp. 52–60.

D. CONCLUDING COMMENTS

Many sources of basic and advanced VE training are available to the Government and industry. SAVE International is an excellent source for keeping abreast of the latest research done in VE, particularly concerning human interaction and overcoming resistance to change. Attending the annual SAVE conferences is one of the best ways to learn the most up-to-date information. (SAVE Conference Proceedings were the source of much supporting information in this paper.)

VIII. VE FROM A CONTRACTOR'S PERSPECTIVE

The purpose of this chapter is to provide information and suggestions that can facilitate the successful development, preparation, submission, and implementation of VECPs to realize the benefits of VE for both the Government and its contractors. It is not intended to make the contractor an expert on VE principles or techniques.[70]

As in all other contractual actions, it is extremely important to read the contract before developing VECPs. This review will acquaint the contractor with specific contract requirements and provisions and could also reveal non-value-added requirements/ provisions that add cost to the performance of the contract. These non-value-added requirements/provisions may themselves be appropriate targets for a VECP submittal if other VECP requirements are met (i.e., a change to the contract is required and the cost of performance could be reduced).

Contractors can obtain additional guidance from (1) the VE clause in their applicable contract; (2) FAR 52.248-1, including Alternates I, II, and III, which provide the basis for contractors to submit VECPs in supplies or services contracts;[71] or (3) their Government contracting office. Personal assistance may be obtained from the customer's VE advocate or from the overall DoD points of contact listed in the appendix to this paper.

This chapter is organized as follows. Section A identifies some contractor considerations for the effective use of VE in Government contracts. Provisions of the VE terms and conditions in contracts are briefly discussed in Section B. Sections C and D provide guidelines for the preparation of VECPs and for sharing VECP-generated savings, respectively.

While an untapped potential exists for flexibility and tailoring the FAR to accommodate the needs of the Government and its contractors, extenuating

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70 This chapter was the basis of "Contractor's Guide to Value Engineering (Version 2.1)," May 2006. Army Pamphlet 11-3, "Value Engineering" (undated), and DoD Handbook 4245.8-H, "Value Engineering," March 1986, were original sources.

71 FAR 52.248-2 and FAR 52.248-3 apply to architect-engineer and construction contracts, respectively.

circumstances in today's contracting environment often add complexity to the VECP process and consequently discourage the use of VECPs.[72]

A. ESTABLISHING AND MAINTAINING AN EFFECTIVE CONTRACTOR VE PROGRAM

A VECP is a proposal submitted to the Government by the contractor in accordance with the VE clause in the contract. It proposes a change that, if accepted and implemented, provides an overall cost savings to the Government. A VECP may update an existing design to the current state-of-the-art technology, simplify complex material by modifying or eliminating components, update specifications/drawings to provide improved data for future procurements, or reduce Contract Data Requirements List items, to name a few examples. Although termed "value engineering," no engineering effort is required; only a proposal that reduces the cost of performance under the contract and requires a contract change for implementation. The VE terms and conditions in a contract prescribe that the contractor receives a substantial share in the savings accrued as a result of implementation of the change.

There is a mistaken belief that a VECP requires a change in a specification. It does not; it requires only a change in the contract. To qualify as a VECP and to ensure that savings can be shared, the proposed change must be submitted under a current contract and must meet two primary requirements:

1. It must require a change to the contract under which it is submitted.
2. It must provide an overall cost savings to the Government after being accepted and implemented. (Note that a VECP could result in increased unit cost but reduced O&S cost. Thus, there would be an overall savings to the Defense Department.)

As in the Government, management support is necessary for successful contractor use of VE on Government contracts. The following is a suggested listing of questions to help determine the attitudes and disciplines needed to have a viable, effective VE program:

1. Does the company establish VECP goals?
2. Do VECP goals flow down the corporate structure?

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[72] See *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts*, IDA Document D-3046, Mandelbaum and Reed, October 2006 for more information.

3. Are contractor management personnel involved in VECP decisions and do they approve VE operating goals and budgets?
4. Do contractor management personnel consult with key Government personnel on the use of VECPs as a cost-reduction tool and gain Government agreement on the need to apply the VE methodology to the system being acquired?
5. How do contractor personnel benefit from contributions to approved VECPs? Are there special awards and/or recognition?
6. Do contract negotiators understand the FAR VE provisions?
7. Are VE sharing provisions, as company policy, in subcontracts?
8. Does the company's accounting department identify VECP income separately so that:
    a. Management personnel can recognize the monetary benefit of VE?
    b. Management can be kept informed of expenditures and receipts resulting from the VE effort?
9. Are resources assigned specifically for the development of VECPs?
10. Does the company work to minimize the time to:
    a. Develop a VECP?
    b. Obtain internal approval before submitting a VECP to the Government?
11. Does the company conduct formal VE workshops to expand in-house capabilities?
12. Is there a VE training and indoctrination program?
13. Is there coordination between Government Contract Administration and the company's marketing efforts with respect to VECPs?

B. VE TERMS AND CONDITIONS IN CONTRACTS

The basic VE provision is the VE Incentive (VEI) clause in the FAR. The VEI clause is included in most supply/service contracts when the contract price exceeds $100,000. It may also be included at lower thresholds. For example, using the clause for spares/repair kit contracts over $25,000, if the contract is not for standard commercial parts, is a common practice among many DoD organizations. The VEI clause may be included in contracts under $100,000 if the contracting officer sees a potential for significant savings. If the VEI clause is in the contract, contractor participation is voluntary. However, when contractors do participate in the VE program by originating, preparing, and submitting VECPs, they will be rewarded for their (and any of their subcontractors') ideas if the ideas are adopted by the procuring activity. The sharing rate (percentage of the savings) received by the contractor is specified in the FAR.

In addition to the basic VEI clause, the FAR contains alternative provisions that can be incorporated into a contract that requires a mandatory VE effort by the contractor. Known as the VE Program Requirement (VEPR) clause, it may be included in initial production solicitations and contracts for major programs if the contracting officer determines that significant savings may result from a sustained, specified VE effort. Typically, solicitations and contracts employing a VEPR include a Statement of Work, a Contract Data Requirements List requirement for submittal of VECPs, and a separate Contract Line Item. The VEPR clause can be used as a risk-sharing mechanism where the parties to the contract may agree to share development costs. Unfortunately, the use of the VEPR has declined in the Department due to the extensive amount of Government preparation and oversight that is required to manage it.

1. When No VE Provisions Are Included in the Contract

It is possible that a contractor could have an idea for a VECP but has a contract containing no VE provisions. In this case, the contractor should notify the Procuring Contracting Officer (PCO) that it would like to submit a VECP. The contractor should request that a contract modification be issued as soon as possible to incorporate applicable FAR provisions. Normally, VEI provisions will suffice. However, if the contractor's idea will require significant initial funding and the marketing/pre-sell efforts have indicated that the Government is interested, the contractor may request the VEPR provision.

2. Subcontractor VE

The FAR requires prime contractors to extend VE provisions to their subcontractors on contracts of $100,000 or greater. It is recommended that VE provisions should also be extended to subcontractors on contracts of lesser value unless the nature of the work precludes VE benefits. A subcontractor must submit its VECP to the prime contractor who, in turn, submits it to the Government.

3. VE and Performance-Based Contracts

Recent changes to promote acquisition excellence have mandated the increased use of performance-based contracts. Performance-based contracting is believed to be eliminating the contractor's incentive to submit VECPs because under a performance-based contract, contractors can make changes without Government approval and keep all the savings. There are, however, a number of reasons why a contractor would submit a

VECP and share the savings with the Government. In situations where there are high development and implementation costs, new/risky technologies, changes that require Government test facilities, or changes that affect the acceptance of products, it is mutually beneficial for contractors to submit (and the Government to accept) VECPs. Without VECPs, the contractor would most likely refrain from any investment because of the risks involved. In addition, even in a performance-based contract, there are still some areas that remain under Government control for which VECPs may be submitted. Finally, in a contract where cost and pricing data may be collected, it often is beneficial for a contractor to submit a VECP to secure a share of future savings that otherwise would typically be negotiated away as general efficiencies.

C. PREPARING VECPS

VECP preparation encompasses marketing the idea, gaining informal Government approval, developing the required information, and formal submission.[73]

1. VECP Marketing

VE clauses in DoD contracts are not enough. The clauses merely invite or require contractors to question the value of Government specifications, statements of work, and those requirements that contribute nothing (except cost) to the contract tasks or items being acquired.[74] Both parties (Government and contractor) must work together to capture the actual benefits of VE efforts.

As with any change to an active contract, communication between the contractor and the approving authority is critical because a VECP is a change to the contract and thus a change to the program. A program manager's primary concerns are schedule, performance, and cost. Any change that could have an impact on any of these areas requires early discussion and general agreement from all parties involved, including the PCO and the Administrative Contracting Officer for the particular contract.

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73 Chapter IX, Section B, provides additional information on these subjects in the context of a VE community of practice.

74 Keep in mind that certain contractual requirements such as Contract Performance Reports, Cost and Software Data Reports, Integrated Master Schedules, and Contract Funds Status Reports may not seem value-added from the contractor's standpoint, but convey valuable management and financial information to the Government, are required by regulations, and cannot be waived in the course of value engineering.

Because the cost of preparing a formal VECP is often quite substantial, the contractor needs to pre-sell or market the VE idea. Through clear communication with the procuring activity, pre-selling enables the contractor to get an indication from the Government of whether a potential idea should be pursued. The contractor should get to know the Government point of contact/Government VE advocate who has the responsibility for evaluating and accepting/approving the VECP. A potential VE idea should be presented as early as possible to the appropriate points of contact.

This informal submission may take the form of a slide (or other) presentation that describes and details the technical aspects of the idea, lists its advantages and disadvantages, estimates the cost to implement and the potential cost savings, and meets as many of the eight FAR 52.248-1 requirements as possible. A contractor is not required to make an informal submission, but doing so is likely to improve the contractor's chances of success, especially if the development of the idea presents the possibility of significant risk to the contractor or the program. This presentation can help the Government determine whether the idea deserves additional consideration or should be abandoned. If the Government is receptive to the idea, the contractor can request the Government's views on qualification and testing requirements as well as other Government cost impacts. The contractor should be aware that the Government's validation that the preliminary proposal has potential to be accepted as a VECP does not guarantee that the VECP will be accepted or approved, nor does it guarantee ownership of the idea. Also, the Government's favorable response does not obligate the contractor to submit a VECP, nor does it obligate the Government to pay for effort already expended on the VE initiative.

While a preliminary informal submission does not eliminate all risk to the contractor, it reduces one major element of contractor risk by preventing a contractor's expenditure of significant funds and time on ideas that have little or no chance of being accepted or approved. In rare cases of concurrent competitive contract efforts, an independent formal submission of a VECP from a competitor may preempt the favorable consideration of a preliminary proposal. The Government is prohibited from unilaterally "using" a contractor's VECP idea or sharing it with a competitor, but there is no prohibition on competitors independently pursuing similar efforts and making independent formal submissions.

The contractor should also be aware that an informal submission does not establish ownership of a VE idea or the right to share in any resultant savings. This ownership is established only when a fully documented formal VECP is submitted.

In summary, preliminary submission of ideas for a VECP is advantageous to the contractor in that:

- It establishes a "date of record" for contractor development costs incurred in preparation of the VECP.
- It reduces the risk of expending time, effort, and funds on an idea that the Government does not want to pursue.

2. Basic Requirements of the Formal VECP

When the contractor makes the decision to submit a VECP, those responsible for preparing it should realize that the chance of the VECP being approved is proportional to the completeness of its preparation. Sufficient information must be provided so that the Government can conduct a thorough evaluation within a reasonable amount of time. Failure to provide adequate data will usually result in a request for additional data (which significantly delays the process) or could possibly result in the VECP being rejected. The contractor should prepare a VECP using an approach similar to responding to a formal procurement solicitation. The following is the FAR description of the minimum information required for a VECP submission:

1. Describe the difference between the existing requirement (i.e., the basic contract, a specification, a drawing, or the Statement of Work) and the proposed change. List the comparative advantages and disadvantages of each alternative. Provide justification when a function or characteristic of an item is being altered. Describe the effect the proposed change will have on the performance of the end item. Include pertinent objective test data.
2. Make an analysis and itemization of each contractual requirement that must be changed if the VECP is accepted. Describe and price each contract change. Include any recommendations for changing specifications.
3. Identify the first unit (or item, task, etc.) that will be affected by the VECP.
4. Provide a detailed cost estimate for both the old and proposed methods. Make sure estimated contractor developmental and implementation costs are accounted for as well as any costs attributable to subcontractors. In many cases, a rough-order-of-magnitude estimate should be used to expedite VECP submittal. Updated cost data can be provided while the VECP is going through technical review. It is a good idea to distinguish between recurring and nonrecurring costs.
5. Provide a description and estimate of costs the Government may incur in implementing the VECP, such as test and evaluation or O&S costs.
6. Predict, as close as possible, the collateral cost savings or increases that the Government will experience once the VECP is implemented.

7. Identify the point in time at which a contract modification implementing the VECP must be issued to maximize possible savings. Note any effect the contract modification will have on the delivery schedule or contract performance time.
8. Identify any previous submissions of the VECP, giving the dates submitted, agencies involved, contract numbers, and previous actions by the Government, if known.

a. Format of the Formal VECP

The FAR clause relative to VE does not specify a particular format to be followed in preparing a VECP. Configuration management should be performed in accordance with the terms of the contract. Any questions should be directed to the Government contracting officer.

b. Where to Send VECPs

The FAR governs the distribution of VECPs. The clauses for supply/service contracts require that VECPs be submitted to the PCO and to the ACO when the contract is administered by other than the Defense customer (e.g., Defense Contract Management Agency). Copies should also be sent to the appropriate Program Office and to the Government VE Office/advocate.

The Government VE advocate monitors all VECPs received and, through close coordination with the PCO and Program Office, facilitates timely processing. The Government VE advocate can also serve as a point of contact from which the contractor may obtain the status of the VECP.

c. Transmittal Letter

Preparation of a transmittal letter forwarding the VECP is also a important step toward success. The transmittal letter should state that the VECP is being submitted pursuant to the VE provisions of the contract. The transmittal letter should also serve as a summary of the contents of the VECP and should briefly state the nature of the proposed change, estimated price changes, and reference where complete details can be found in the proposal. The transmittal letter serves as a table of contents of the proposal and as a marketing document, highlighting the proposal’s technical advantages and overall cost reductions to the Government.

d. Restricting Data

Normally, the Government has unlimited rights to use the data in a VECP. If a VECP contains information that the contractor wishes to restrict from use prior to Government approval, the contractor should include an appropriate legend on each page of the VECP. The FAR language for supply/service contracts for this legend is as follows:

> This data, furnished under the VE clause of Contract No. _____, shall not be disclosed outside the Government or duplicated, used, or disclosed, in whole or in part, for any purpose other than to evaluate a VECP submitted under the clause. This restriction does not limit the Government's right to use information contained in these data if it has been obtained or is otherwise available from the contractor or from another source without limitations.

If the VECP is accepted, however, the Government normally has the right to use any and all data contained in the VECP and its supporting documents.

If the VECP contains proprietary data that the contractor wishes to restrict even after acceptance of the VECP, a statement to that effect must be included in the VECP. The proposal should be marked with the appropriate limited rights legend from the "Rights in Technical Data and Computer Software" clause of the DoD FAR Supplement, and the contractor must explain in the proposal the basis for asserting limited rights. The contract modification implementing the VECP should specify the limited rights that the Government has accepted. The contractor should realize, however, that a VECP that results in a "sole source" condition for future acquisitions might not be as readily accepted as one for which this restriction is not imposed.

3. Additional VECP Guidelines

The following additional guidelines apply when preparing VECPs:

- When a contractor submits a VECP for approval, the contractor should not initiate action to implement the change until the contractor receives a formal contract modification approval from the Government.
- When a contractor submits a VECP, the contractor should identify other similar or related contracts to which the VECP may apply (if known). Identify the potential to have other program customers participate in the VECP nonrecurring cost (e.g., foreign military sales customers).
- When a contractor undertakes a VECP effort, the contractor must keep records of development costs and require that subcontractors do the same.

- Contractors should be as accurate as possible in calculating implementation costs and insist that the Government provide accurate and complete data when calculating Government implementation costs.
- When a VECP is incorporated into the contract(s), the contractor should maintain internal records identifying the first delivered item containing the VECP.
- The contractor may withdraw the VECP in whole or in part prior to acceptance/rejection. However, any such withdrawn VECP or portion thereof, may be subsequently incorporated into the contract without payment of a share of the cost savings to the contractor. This mechanism helps preclude a possible situation where the contractor, not satisfied with the contracting officer's determination of the worth of a VECP and the associated share in cost savings, withdraws the idea to place the contracting officer in an unfair negotiating position.

D. SHARING VECP SAVINGS

The Department of Defense has been encouraging submission of VECPs since the VE policy was first established in the FAR. Many changes that have occurred over the years have clarified the FAR language and increased the contractor's share of savings.

Acquisition and collateral savings are two basic types of savings that can be shared when a VECP is approved and implemented under a supply/service contract. Subsections 1 and 2 describe the sharing arrangements for firm-fixed-price contracts with VEI provisions and Subsection 3 discusses sharing arrangements with subcontractors. Sharing arrangements vary with other types of contracts. FAR Part 48 and 52.248-1 define the terms used in VE, the criteria for VECP acceptance, and the approved sharing rates. In addition, incentive contracts may contain special provisions to ensure that no adjustments are made to targets or ceilings when a VECP is approved. This results in instant contract VECP savings being rewarded under the overall contract cost incentive. Whatever the type of contract, it is the Government's intent to offer a full range of motivational VE options to contractors while precluding duplication of incentives.

1. Acquisition Savings

The FAR defines *acquisition savings* as "savings resulting from the application of a VECP to contracts awarded by the same contracting office or its successor for essentially the same unit." Acquisition savings may include savings obtained on the instant contract, concurrent contracts, and future contracts.

The instant contract is the contract under which the VECP is submitted and accepted. As the VECP is implemented on items delivered under this contract, the contractor will receive a percentage share of the net savings that accrue as a result of the VECP. In calculating these savings, the contractor's (and, if applicable, subcontractor's) reasonable, allowable, and allocable costs for development and implementation of the VECP and the Government's costs for implementation are all taken into consideration. A contractor's development costs are those costs incurred in developing, testing, preparing, and submitting the VECP. Development costs materialize after it has been determined that a VECP will be prepared and before acceptance of the VECP by the Government. Implementation costs are those costs resulting from contractual changes required as a result of Government acceptance of the VECP. Implementation costs are incurred after the VECP has been approved. For audit purposes, the contractor must identify and record those costs incurred (including subcontractor costs). In calculating any adjustment in this contract's price for instant contract savings (or negative instant contract savings), the contractor's allowable development and implementation costs shall include any subcontractor's allowable development and implementation costs and any VE incentive payments to a subcontractor that clearly result from a VECP accepted by the Government under this contract. The contractor may choose any arrangement for subcontractor value engineering incentive payments, provided that the payments shall not reduce the Government's share of concurrent or future contract savings or collateral savings. The arrangements negotiated for the instant contract are continued in future contracts, including any negative instant contract savings for the contractor submitting the VECP to the Government.

Concurrent contracts are those contracts that the VECP originator (referred to as Contractor A) and other contractors (Contractors B, C, etc.) have ongoing at the time the VECP is approved for essentially the same item. If the Government directs that Contractor A's VECP be incorporated into Contractor B or C's contract, then Contractor A will receive a share of the net savings obtained from contracts B or C (any contract affected by Contractor A's VECP). Contractor A's instant contract total price will then be increased by that amount.

Acquisition savings can be shared in one of three ways. If the Government can predict with some degree of certainty the number of affected items to be procured within the share period (and this number is not classified), the "lump-sum" method of settlement can be used if the contractor and the contracting officer so agree. The contract modification incorporating the VECP will specify the anticipated future procurement

quantity. The cost savings per unit are then multiplied by the anticipated share period quantity, and the instant contract price is increased by the contractor's share of that amount.

The primary way of sharing future savings is where the contractor receives a portion of the per-unit savings that occur either as contracts incorporating the VECP are awarded or as VECP-affected units are delivered. This sharing applies to items scheduled for delivery within the determined share period (as described in the FAR), which begins upon acceptance of the first item affected by the VECP. In the case of multiyear contracts, sharing applies only to quantities that (1) are fully funded at the time of VECP acceptance and (2) fall within the determined share period. It is the contractor's responsibility to maintain records from the time the first VECP-affected unit is accepted until the determined VECP share period ends. Whenever the Government issues a new contract during this share period for essentially the same item, and the contractor's VECP has been incorporated into the contract documents, the contractor is entitled to a portion of any per-unit savings during the share period. Payment will be made via the instant contract when savings are realized. Normally, the savings per unit calculated for the original contract will be multiplied by the number of units scheduled for delivery before expiration of the share period. Also, in design or low-rate initial production contracts, the Government may modify the usual VE clause to improve contractor incentives. If the clause is so modified, the sharing formula is expressed in terms of a specific quantity and not in time. This quantity is the number of units affected by the VECP that are scheduled to be delivered over a period of between 36 and 60 consecutive months (set at the discretion of the contracting officer for each VECP as described in the FAR) that spans the highest planned production, based on planning and programming or production documentation existing at the time the VECP is accepted.

The third way of sharing savings with the contractor is the "no-cost modification" method. Under this method, the contractor keeps all savings from the instant contract and its own concurrent contracts. The Government keeps all savings from future contracts and concurrent contracts with other sources as well as all collateral savings. This method, if agreed upon by both the Government and the contractor, can minimize the administrative costs of determining and negotiating savings.

If the "lump-sum" method or the "no-cost settlement" method cannot be mutually agreed upon, then the future per-unit savings method will be used.

2. Collateral Savings

Collateral savings are those measurable net reductions in cost of operation, maintenance, logistics support, shipping, or Government-furnished equipment, which result from an accepted VECP. In some situations, a VECP might increase the acquisition cost of an item but result in substantial collateral savings. For collateral savings, the contractor is entitled to 20 percent to 100 percent (determined by the contracting officer as described in the FAR) of the savings that the Government estimates will be realized during an average 1-year period. However, the contractor's share shall not exceed $100,000 or the value of the instant contract, whichever is greater. The Government determines the amount of collateral savings. Some contractors have had several VECPs approved and implemented with substantial collateral savings. However, determining and verifying measurable net reductions can be difficult and, in some instances, the Government may exclude the collateral savings program.

3. Sharing Savings with Subcontractors

As discussed previously, the prime contractor's allowable development and implementation costs shall include any subcontractor's allowable development and implementation costs and any VE incentive payments to a subcontractor that clearly result from a VECP accepted by the Government under this contract. The contractor may choose any arrangement for subcontractor VE incentive payments provided that the payments shall not reduce the Government's share of concurrent or future contract savings or collateral savings.

Prime-to-subcontractor VE arrangements can be made by the prime contractor, extending to the subcontractor any or all of the instant contract savings and/or a percentage of whatever amount the prime contractor receives as its share of concurrent contract share, collateral share, and future acquisition share. For example, a simple paragraph could be included in a subcontract that might provide a 50-percent share of whatever dollar amount the prime contractor receives in the four areas of sharing on a successful VECP.

The sharing between prime contractor and subcontractor can be a matter of negotiation between them and should provide motivation for the subcontractor to submit VECPs to the prime contractor. It should also provide a fair share to the prime contractor, who is responsible for putting a subcontractor's VECP into proper format and for "selling" it to the Government. Any development and implementation costs incurred by

the subcontractor, and the share of instant contract savings extended to the subcontractor, are considered to be a part of the prime contractor's development and implementation costs.

E. CONCLUDING COMMENTS

Because VE is the only incentive program with a predefined means for contractor sharing in savings, it represents a valuable means of increasing a contractor's margins while also providing savings to the Defense Department. The success achieved is proportional to the resources invested in the effort. Having a formal VE program to establish policies for promoting VE with subcontractors, market VE, and provide guidance regarding the basic requirements of submitting a VECP will increase a contractor's success.

IX. PROMOTING VE IN GOVERNMENT AND INDUSTRY

A. BACKGROUND

Under Secretary of Defense (Acquisition, Technology, and Logistics) Kenneth Krieg explains the importance of VE to national security:[75]

> The principles of Value Engineering—to be effective and efficient—are at the very core of everything we do here at the Department of Defense. We are all responsible for making sure the warfighter has what he or she needs to get the job done. Nothing is more important than doing our part to make sure they have what they need to protect the American people, as well as our friends and allies. We are here to make sure that our troops can defend freedom, and eliminate tyranny, right here at home, and abroad. Fighting and winning the Global War on Terror demands that we spend the taxpayers' dollars wisely. Therefore, we need to do everything we can to, one, streamline operations, two, reduce costs, and three, improve quality and efficiency. And that is what Value Engineering is all about. It is one of the most effective tools available to help us bring projects in on time and on budget.

Despite such endorsements and despite VE's proven track record of generating approximately $1 billion annually in cost avoidance and savings (see Figure 2 in Chapter I), there is a great deal of unrealized potential, especially for VECPs. A 1997 VE Process Action Team report identified a number of barriers to the increased use of VECPs.[76] Since that time, many of these barriers have been mitigated as discussed below.

From the viewpoint of a Program Manager:

- An R-TOC program element has been established to fund up-front, nonrecurring costs associated with cost-reduction initiatives with a high return on investment.
- Although programs are not entitled to the savings generated from cost-reduction initiatives, in some cases, they have been allowed to keep them.

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75 Remarks by the Honorable Kenneth J. Krieg, Under Secretary of Defense (Acquisition, Technology and Logistics), Value Engineering Awards Ceremony, 15 June 2005.

76 "Final Report of the Process Action Team on Value Engineering Change Proposals," Office of the Under Secretary of Defense for Acquisition and Technology, May 1997.

- *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts*, IDA Document D-3046, Mandelbaum and Reed, October 2006, shows untapped potential for flexibility and tailoring allowed by the FAR to accommodate the needs of the Government and its contractors.
- As a result of the Office of the Secretary of Defense's reinvigoration of systems engineering, VE is receiving increased attention from a policy perspective, especially in the context of its relationship with the R-TOC initiative.

From the viewpoint of a contractor:

- The FAR was modified to give the PCO the flexibility to increase the contractor savings share from 50 percent to 75 percent, to extend the sharing period from 3 to 5 years, and to raise the contractor collateral savings share from 20 percent to 100 percent of an average year's savings.
- The previously referenced *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts* and the update of the *Contractor's Guide to Value Engineering* associated with this document[77] provide a great deal of helpful information.

Additional effort is ongoing in two areas—greater leadership attention and improved VE know-how. Increasing VE expertise by itself is not enough. Similarly, management emphasis, without the know-how, will not be especially effective. Chapter VI provided some best practices for establishing a VE program, a key element of which involved top management support.[78] The remainder of this chapter deals with building VE know-how in both the Defense Department and industry.

B. BUILDING AND USING A VE COMMUNITY OF PRACTICE

One of the most effective ways of improving expertise in a subject is to link knowledge seekers with knowledge sources (both written and experiential). Communities of practice (CoPs) are proven vehicles for making these connections, for linking people with experience to others who can benefit from their insight and knowledge.

A CoP is a group of individuals with similar interests that works together to facilitate communication, share knowledge, and solve common problems. CoPs cross organizational lines and geographical boundaries. By nurturing a trust-based culture,

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77 See Chapter VIII.

78 Additional and continuous high-level emphasis by senior Office of the Secretary of Defense leadership both within the Defense Department and to industry will also help significantly. Further discussion of this topic is outside the scope of this document.

CoPs foster interaction among people at different levels and with varying subject matter expertise; they enable personal relationships with leaders in the field. By providing a safe environment to share challenges, exchange best practices, and test new ideas, CoPs stimulate collaboration and innovation.

Such an approach is being applied to VE. The CoP initially focused on VECPs has been organized to help practitioners share and learn from one another. The CoP can be accessed by going to the Defense Acquisition University's Acquisition Community Connection Web site, https://acc.dau.mil/vecp. The CoP will help participants navigate the VECP process, improve the probability of successful VECP evaluations, provide assistance and answers to technical questions, and serve as a forum for disseminating the latest information. Contracting officers, VE practitioners, program offices, and industry are all encouraged to use this CoP to share and build on the material in this document.

Figure 8 captures the opening page of the Defense Acquisition University Community Connection Web site. It shows the four major elements of the VECP process—idea generation, selling the VECP, VECP approval, and VECP settlement. The additional information provided on each of these four topics is reproduced in Subsections 1 through 4, respectively. Each of these subsections describes its corresponding portion of an overall flowchart (extracts of which are shown in Figures 9–12) of the VECP process. Yellow blocks signify contractor activities for which further information is provided; blue blocks signify Government activity for which further information is provided. The widespread dissemination and use of this information, along with sharing other knowledge and experience, will help advance VE strategic objectives and provide increased profit and other benefits to the contractor; the Defense Department will benefit from cost savings and improved system performance.

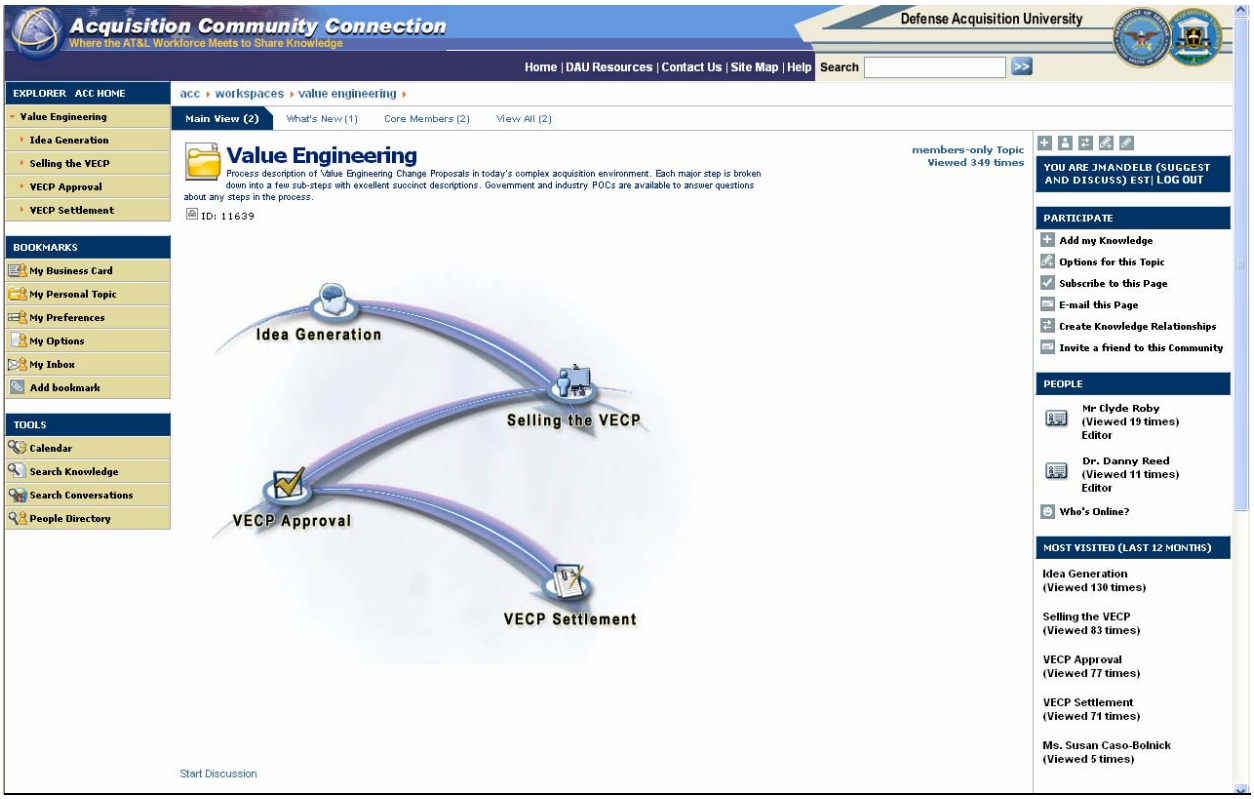

Figure 8. Entering the VE Community of Practice

1. Idea Generation

Figure 9 portrays the idea-generation process.

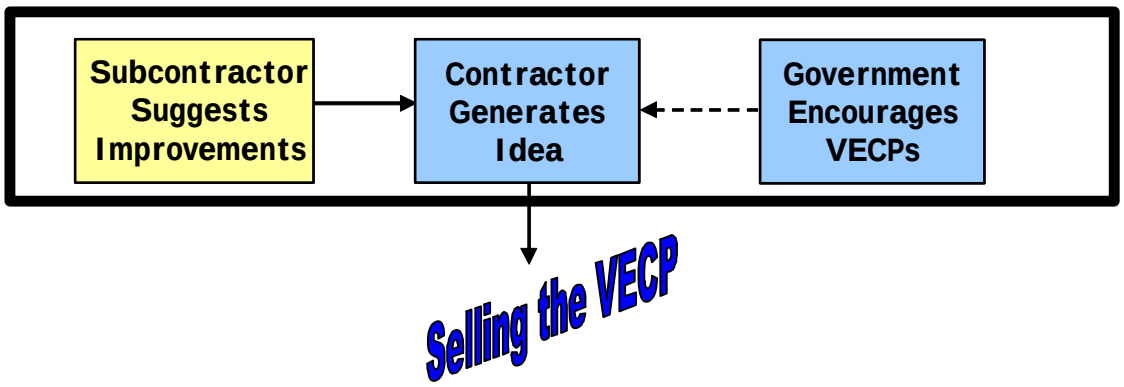

Figure 9. VECP Idea Generation

a. Contractor Generates Idea

The following are some best practices for a viable contractor VE program:

- The company should establish VECP goals
- VECP goals should flow down through the corporate structure.
- Contractor management personnel should be involved in VECP decisions and approve VE operating goals and budgets.
- Contractor management personnel should consult with key Government personnel on the use of VECPs as a cost-reduction tool and gain Government agreement on the need to apply the VE methodology to the system being acquired.
- Contractor personnel should benefit from contributions to approved VECPs in the form of special awards and/or recognition.
- Contract negotiators should understand the FAR VE provisions.
- VE sharing provisions should be in subcontracts as company policy.
- The company's accounting department should identify VECP income separately so that:
  - Management personnel can recognize the monetary benefit of VE.
  - Management can be kept informed of expenditures and receipts resulting from the VE effort.
- Resources should be assigned specifically for developing VECPs.
- The company should work to minimize the time to:
  - Develop a VECP.
  - Obtain internal approval before submitting a VECP to the Government.
- The company should conduct formal VE workshops to expand in-house capabilities.
- There should be a strong VE training and indoctrination program.
- There should be close coordination between Government Contract Administration and the company's marketing efforts with respect to VECPs.

b. Subcontractor Suggests Improvements

While only the prime contractor can submit a VECP, many potential ideas can be developed by a subcontractor.

- Prime contractors and their subcontractors have a unique contractual relationship; the Government customer has no involvement.
- The Government customer deals only with the prime contractor.
- The entire supply chain can benefit from reducing system cost, increasing performance, and accelerating fielding.
  - It makes the prime contractor more competitive.

  - It strengthens the business relationship between the prime contractor and its subcontractors.
  - Savings can be shared.
- The prime contractor should encourage its subcontractors and their suppliers to participate in VECPs.
  - Prime contractors should have a business plan for encouraging subcontractor involvement in VE process. This plan may be developed jointly with the Government customer.
  - Incentives may be offered.
  - It could be a way in which suppliers are evaluated.
  - Prime contractors often develop "roadshow briefs" on VECPs for subcontractors or convene periodic meetings to address/resolve prime contractor-subcontractor issues. These meetings are opportunities to address VECP opportunities and rewards with subcontractors. A joint Government/prime contractor/subcontractor VE workshop is an excellent way to substantiate the benefits to all parties.
- The subcontractor should propose a business plan to the prime contractor to maximize VECP benefits for all parties—prime contractor, subcontractor, and Government customer. The proposed change could affect other contracts the prime contractor has with the subcontractor or other business the subcontractor may have with other companies. If there is a large investment required, a way may be found to minimize the nonrecurring expenses to the instant VECP by spreading these costs over multiple programs. The prime contractor may be willing to pay large nonrecurring expenses that cannot be offset on the current contract for some consideration or may offer greater returns if the subcontractor provides the funding. Other business that they conduct with each other could affect their willingness to initiate the VE effort and might be considered.
- The way in which savings are split is entirely dependent on the negotiations between the prime contractor and the subcontractor. The FAR VE clause (FAR 52.248-1(l)) requires the prime to insert "an appropriate VE clause" in all subcontracts of $100,000 or more and may include one in those of lesser value. "Appropriate" should be interpreted as being a clause that sufficiently motivates a subcontractor to prepare and submit VECPs to the prime for further submission to the Government.
  - The Government recognizes the importance of VECPs developed by subcontractors (where 75 percent to 85 percent of the actual work takes place) by allowing (per FAR 52.248-1(l)) the subcontractor to "take the first bite out of the apple" on instant contract savings—even if that means no instant contract savings are left for the prime contractor and the Government to share. However, there must be overall savings for the Government, and

the Government must be the primary beneficiary of all concurrent, future, and collateral savings.

c. Government Encourages VECPs

At a general level, VE advocates should brief program offices about the importance and benefits of VE.

- At every opportunity industry should be told of the Government's interest and receptiveness to VE.
- The Program Manager should use meetings with contractors to express interest in VECPs throughout the acquisition process.
- VE advocates should explain the need for VE to Defense Contract Management Agency representatives, who in turn could present a VE briefing to contractors and try to promote VECP champions in industry.
- The program office should encourage the contractor to think about additional ideas and recommend other areas where the Government would be receptive to VECPs.

2. Selling the VECP

Figure 10 depicts the process of selling the VECP.

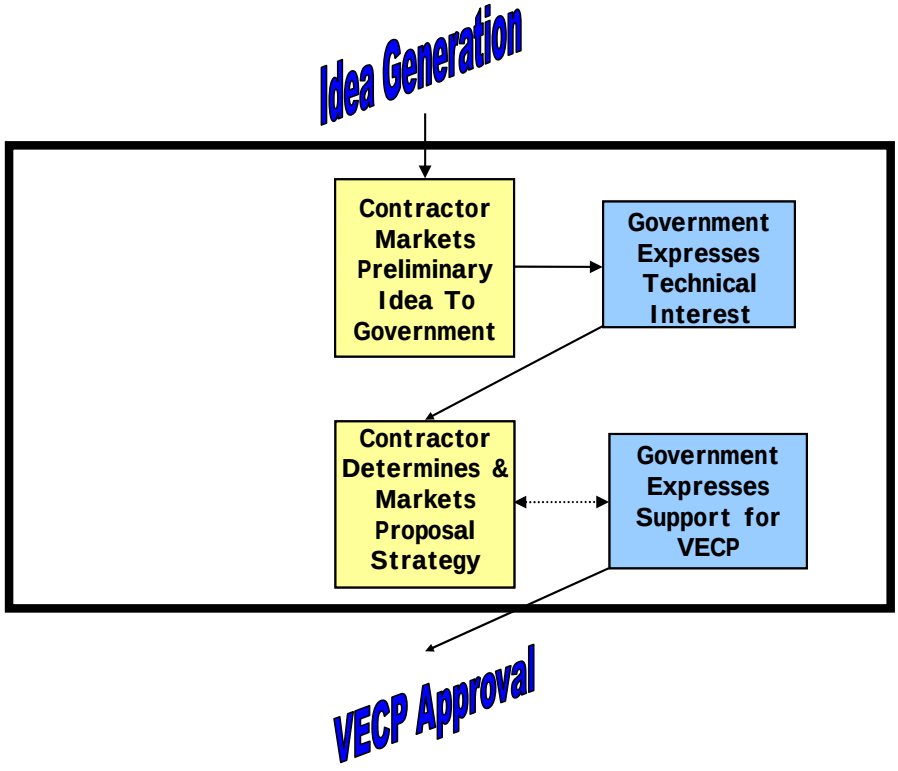

Figure 10. Selling the VECP

a. Contractor Markets Preliminary Idea to Government

This is a low-key activity designed to gauge whether there is any Government interest—it does not, however, generate a commitment by the Government.

- The contractor should brief the idea to the Government technical team or equivalent thereof.
  - There should be limited contractor investment in the briefing.
  - It is a good idea to include a rough-order-of-magnitude pricing and potential savings.
  - The contractor should also indicate potential risks in cost, schedule, and performance.
  - It is important to address when the VECP effort would be completed (i.e., when the new configuration is tested and qualified). The Government can make a VECP uneconomical by expending all the savings on expensive testing. This is more likely to happen with missiles and aircraft because of safety, but it is always a concern. That is why "qualification" is included even in some preliminary briefings. The contractor wants the Government to agree that its approach seems correct. For example, the contractor might suggest that if a flight test is required, it be a "ride along" as part of another flight test so there is virtually no cost.
- It is generally advantageous from a customer acceptance perspective to also include a short synopsis or information paper.
- Contractors should also seek feedback on Government needs.
  - Should the idea be modified?
  - Would the Government be receptive to VECPs in other areas?
- Desired outcome: a statement of Government interest and technical feasibility.
  - The Government should tell the contractor exactly what additional technical information should be provided when making a more formal presentation.

b. Government Expresses Technical Interest

View the contractor's suggestion as an opportunity for the Government to save money and improve performance.

- Ensure the right people are present.
- Be constructive; make suggestions on how the ideas can be improved.
- Provide the contractor with an honest and complete assessment of what is presented as well as additional technical information needed.

c. Contractor Determines and Markets Proposal Strategy

Below are some of the key questions the contractor considers before formally presenting the idea to the Government:

- How the VECP should be proposed: either as a "voluntary" effort on its part (maximum risk but maximum savings) or as a "mandatory" clause incorporated in the contract (risk reduced due to Government sharing the risk and Government funding all or part of the development and implementation costs; because of the reduced risk, there is reduced sharing benefit to the contractor).
- Who (contractor or Government) should invest what and when for maximum savings and return.
- How big or small the VECP (assuming it is not a simple one-item change) should be. When dealing with long, stable production runs, it may be desirable to break the proposed change into two or more VECPs to ease processing or approval, or it may be helpful to lump several smaller changes into one big change. Combining ideas may be done for marketing purposes. Often the Government wants to change something, but cannot afford to do so. The contractor might incorporate the Government's desired change into the VECP (even though the Government-desired change saves little or nothing). By letting the Government-desired change and become a part of the VECP, the contractor can make the VECP more marketable. The same would hold true for some things the contractor wants to change that would not be economically viable unless part of a larger VECP.
- Which contract could/should be the instant contract. Among the many factors to consider are which contract will have the most impact, re-bid considerations, and so on.
- What the implementation schedule, including savings period/share (3 to 5 years), should be.
- When the activity should be started. The contractor should explain how it might be accomplished as soon as possible.

The contractor should prepare a formal presentation to the Government justifying the VECP.

- On simple VECPs, a formal presentation may not be required, just a courtesy phone call to the recipient with the offer to provide further information.
- Otherwise, this is the most important facet of the VECP process.
- The briefing is normally made to the Program Manager and all relevant stakeholders (finance, technical, logistics and contracts); the activity VE point of contact/expert/advocate should also be included.

  - Coordinate with the Program Manager to ensure the proper attendance (Government and contractor).
  - Clarify agenda and discussion topics. Talk with the Government counterparts about exactly what people will want to see.
- Desired outcome: Government provides all the feedback necessary for the contractor to submit a VECP and there is buy-in from the Program Manager.
  - This feedback should be worded carefully so that an "approval contingent on the additional information being provided" is not implied. The Government cannot imply approval at this point, it can only indicate level of interest and potential concern areas or suggest information to be provided. Also, the contractor is not obligated at this point to provide anything.
  - Through discussion with the Government, the contractor gains insight into what information would be helpful for the Government to make a technical and contractual decision on the VECP.
  - There is usually a lot of interaction at the meeting. It is important for the contractor to deal with questions on negative impacts (if any) by showing how far the benefits outweigh them.
- Maintain interaction with the Government as needed while the VECP is being prepared (important for both parties).
  - Usually the contractor responds to questions or concerns. These could be logistics impacts or questions about testing, or the Government may want to include something else in the VECP. These do not always result in another briefing, but if required, the Contract Administrator or Program Manager would arrange for it.

d. Government Expresses Support for the VECP

The Government must evaluate the idea from a technical and financial perspective. All technical, cost, and logistics concerns should be communicated to the contractor at that time.

- The Program Manager or his representative should tell the contractor how to modify the idea to make the VECP more acceptable.
- The Program Manager should be unambiguous about the desire for a formal VECP.

3. VECP Approval

Figure 11 illustrates the process for VECP approval.

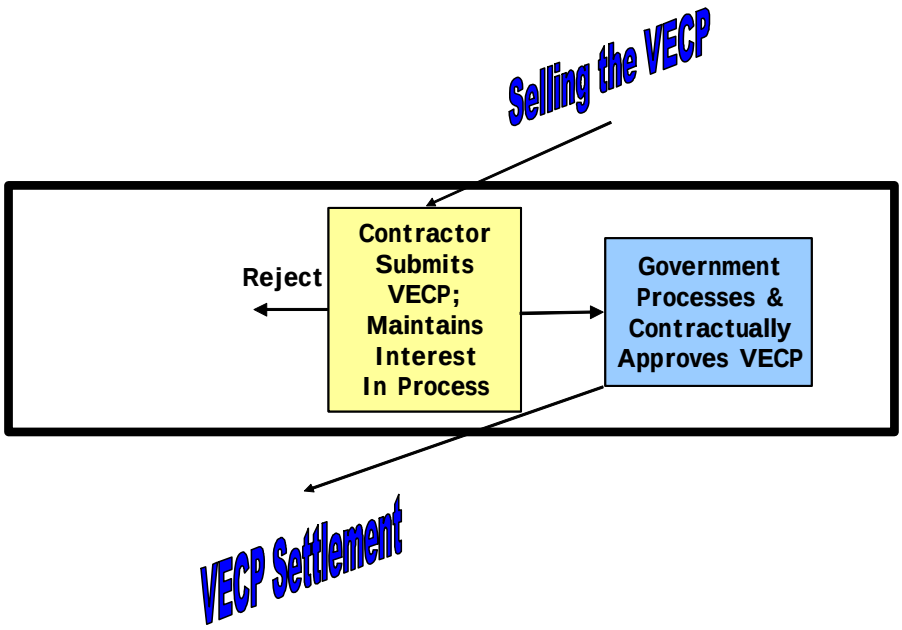

Figure 11. VECP Approval

a. Contractor Submits VECP

Once there is concurrence on the scope of the VECP, the contractor should expedite the in-house preparation of the formal VECP and provide it to the customer as soon as possible after briefing the Program Manager.

- The contractor should work as the contract requires until the contracting officer approves the VECP.
- The VECP is submitted at least to PCO with information copies to Administrative Contracting Officer, VE point of contact, and Program Manager, in addition to any other contractually required distribution.
- If the contractor perceives reluctance on the part of the contracting officer to accept a VECP, it may be a good idea to also send a copy to the overall VE lead for the Command or Component. Because of the greater levels of attention being placed on VECPs, keeping higher headquarters informed can only help. If processing problems are encountered, it just may be possible for higher headquarters to help resolve the issue.
- In the formal submission (often in the cover letter), the contractor should identify terms and conditions and associated rationale for VECP acceptance, share period, savings share, and any required Government investment.
- The Preliminary VECP no longer exists, although some program offices still use the term. It evolved from a time when configuration-management military standards (MIL-STDs) existed. The last MIL-STD on Configuration, MIL-

STD-973, was canceled several years ago with Acquisition Reform. Under MIL-STD-973 and its predecessor standards, contractors could use Preliminary ECPs to propose a change. They were done before all the engineering was complete, but usually after there was enough data to show that the change was, or could be, viable. Preliminary ECPs also included a price. From this evolved the idea of a Preliminary VECP. It was defined as "a full up proposal that included a firm price (or Not To Exceed price), a technical description of the change (including testing or qualification requirements)," and eight other required elements as describe in the VE clause, FAR 52.2481(c). The only thing it did not contain was the actual drawing or configuration changes of the final record ECP or the testing results. Such a submittal would now be a formal VECP.

b. Contractor Maintains Interest in the Process

The contractor should try to find a "champion" in the Government program office (someone who supports the change) to expedite action on the VECP. The VE point of contact may be the champion.

- The contractor should continue to communicate with the Government through the "champion" to check on status and provide answers to questions.
- Sometimes the contractor's local Defense Contract Management Agency can help remind the Government Program office that it needs to act on the VECP to obtain the maximum savings.

c. Government Processes and Contractually Approves VECP

Using an Integrated Process Team to concurrently address all the VECP issues can expedite the Government process. The Program Manager can assist if obstacles occur.

- The VECP must be technically approved as being able to meet the functional requirements.
- The sharing rate will not have to be negotiated if one has previously been agreed upon. If there has not been a previously agreed upon sharing rate, the PCO may consider information (from the Integrated Process Team) such as amount of risk undertaken by the contractor that will help him or her negotiate a fair sharing rate.
- The contract modification approving the VECP enables the contractor to begin work. The PCO can approve or settle the VECP in several ways.
- The PCO can negotiate the rate, settle the VECP, and issue a contract modification.

- The PCO can issue an unpriced order with a not-to-exceed amount cited on the modification and a guaranteed unit savings to be paid by the contractor. This approach may be necessary to meet customer schedule needs and capture high-production quantities. The FAR VE clause recognizes this and, by implication, encourages the Government to accept the VECP technically and then complete any pricing negotiations in a subsequent modification to the contract.
- The Government may also establish a not-to-exceed limit on contractor VECP development and implementation costs as well as establish a not-less-than savings and a not-to-exceed on Government investment. This is usually done when there is a need to expedite VECP implementation and contract modification to ensure that the changes are made on imminent production units.
- When the development and implementation costs exceed the savings on the instant contract, the VECP is implemented through a negative instant contract modification. This means that the Government increases the contract by the amount of the negative savings as specified in the FAR part 48. While the contract price should be increased to cover the negative instant contract saving, it often does not happen because the Government does not have the money. There are ways around this, such as the contractor going on risk for the negative instant contract savings with the understanding that it will be recognized in the next production lot (if there is one) or delaying settling the VECP until the next award so that there are enough savings on the two contracts to avoid any negative instant contract saving.
- Finally, if there is a need to expedite implementation of the VECP, the contracting officer can grant approval to implement the VECP through an undefinitized contractual action or via a Contracting Officer's initial modification per FAR 52.248-1(h). This type of Undefinitized Contractual Action[79] has been addressed in a letter from the Director of Defense Procurement. The letter said that an Undefinitized Contractual Action to technically accept a VECP and permit the contractor to apply the VECP to as many units as possible—thus maximizing VE savings—is acceptable and not to be counted against a contracting office's goal of reducing Undefinitized Contractual Actions to a low level.[80]

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79 An Undefinitized Contractual Action is a new procurement action entered into by the Government for which contractual terms, specifications, or price are not agreed upon before performance is begun (letter contract or change order). Letter contracts and change orders await negotiations to definitize prices. Equivalently, an unpriced change order may be used. An unpriced change order is a change issued within the general scope of, and under the terms of, the contract, for which contractual terms, specifications, or price are not fully agreed upon before performance is begun.

80 A copy of this letter can be found in Appendix A of *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts*, IDA Document D-3046, Mandelbaum and Reed, October 2006.

- Formal VECP implementation and Government final acceptance of the change are subject to the change passing technical qualifications.

4. VECP Settlement

Figure 12 shows the settlement process.

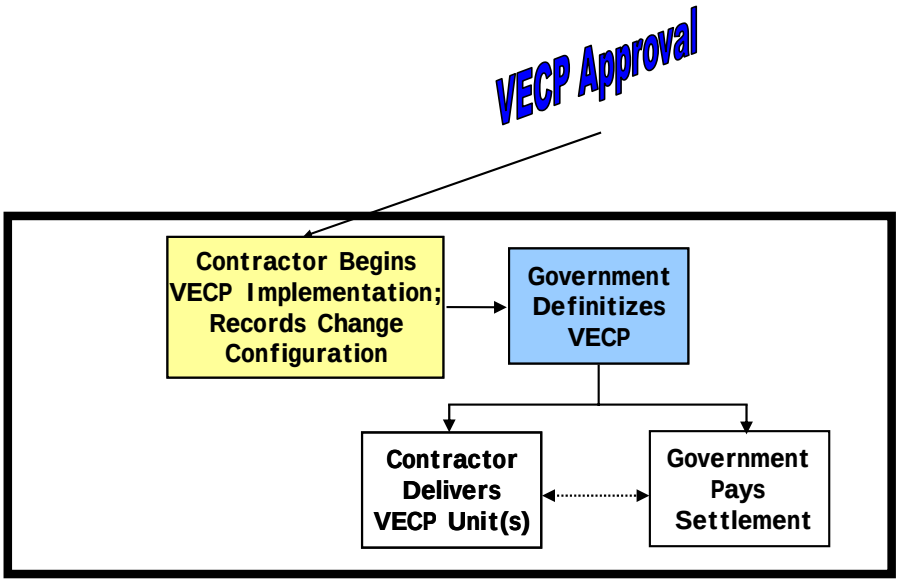

Figure 12. VECP Settlement

a. Contractor Begins VECP Implementation; Records Change Configuration

As a part of the VECP implementation process, the contractor must record the ECP that changes the drawing to incorporate (or allow) the VECP configuration on contracts where the Government retains configuration control. It is usually the last step because it is done after the change has been complete and the new drawings are finalized.

b. Government Definitizes the VECP

Definitizing implies reaching an agreement on future per-unit savings and the schedule for repayment of nonrecurring expenses and other upfront contractor/Government investment.

- The definitizing contract modification generally occurs on the first contract where a VECP unit is delivered.
- Expeditious processing encourages additional VECPs from the contractor. An alpha contracting process is helpful.

- This is a PCO action with assistance from Program Manager/Integrated Process Team/VE point of contact.
- The contractor's value proposition should be accommodated as much as possible.
- Administrative requirements should be minimized.

C. CONCLUDING COMMENTS

Increasing VECP usage is in the best interest of the Government and industry because it improves industry's bottom line and reduces Government cost while delivering greater capability to the warfighter. Many contracting officers, program managers, and their contractor counterparts see only a few VECPs in their career. It is therefore important for both the Government and industry to build upon this expertise, learn from others, and share best practices to formulate and implement VECPs. A knowledge-based CoP is one of the most effective mechanisms to facilitate such sharing. Once people begin exploiting the opportunities provided by VECPs, their use will become self-perpetuating.

APPENDIX:
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ABBREVIATIONS

AEOG	Automated Electrolytic Oxygen Generator
CAIV	Cost As an Independent Variable
COAST	Common Organizational Level Armament Support Tester
CoP	Community of Practice
DFAS	Defense Finance and Accounting Service
DoD	Department of Defense
FAR	Federal Acquisition Regulation
FAST	Function Analysis System Technique
FOC	Full Operational Capability
FY	Fiscal Year
IDA	Institute for Defense Analyses
IOC	Initial Operational Capability
JSOW	Joint Stand-Off Weapon
LEFRA	Leading Edge Flap Rotary Actuator
MIL-STDS	Military Standards
O&S	Operations and Support
OMB	Office of Management and Budget
PCO	Procuring Contracting Officer
R-TOC	Reduction of Total Ownership Costs
SAVE	Society of American Value Engineers
TCI	Time Change Interval
TRIZ	Theory of Inventive Problem Solving
VE	Value Engineering
VECP	Value Engineering Change Proposal
VEI	Value Engineering Incentive
VEPR	Value Engineering Program Requirement

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14. ABSTRACT

The Defense Department can no longer afford the extensive time delays and increased costs that major defense acquisition programs have experienced in the past. This paper shows how Value Engineering (VE) can be an effective mechanism for saving or avoiding costs for both contractors and the U.S. Government. It details the basics of the VE methodology, discusses how to establish a VE program, explains how VE can impact success, describes best practices for applying VE on Government contracts, and provides an overview of the benefits of a strong VE program. The successful application of VE requires a systematic approach for managing a program within an organization, providing practitioners with the necessary training, working with contractors to encourage and support their participation, expediting contractual approval, and sharing pertinent information with others who want to do the same.

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